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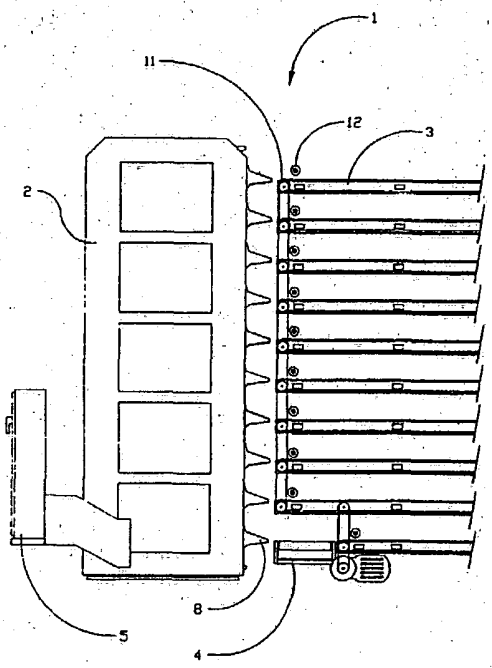
(57) Abstract

System and method for storing, sorting or holding articles, such as trayed mail and other containerized items. The apparatus (1) is comprised of: one or more vertically oriented sorters (2), for the transport and sorting of articles; buffer conveyors (3), for the storing of articles; devices to transfer articles between the lift and the buffer conveyors; a lateral transfer conveyor for entry of articles to and from the system; and a control system with electrical panels, a programmable controller and a computer. A lift conveyor (2) is comprised of a vertically oriented carrousel containing carriers to transport articles along the path of the lift conveyor. The lift conveyor is endless with a reversible driver to convey articles, in either a forward or a reverse direction. Buffer conveyors serve to store articles. The buffer conveyors are an extension of the lift conveyor, increasing the capacity of the lift conveyor.



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INDEXING, BI-DIRECTIONAL VERTICAL SORTER WITH BUFFER CONVEYORS

BACKGROUND OF THE INVENTION

Field of the Invention:

Postal matter, such as letter mail and flats mail is most commonly transported from one operation to another, or from one General Mail Facility to another, in containers known as letter trays or flats trays respectively. The present invention relates primarily to storing, buffering and sorting of trayed postal matter, such as letter mail or flats mail.

Description of Prior Art:

Recent developments in the degree of mechanization of letter mail and flats mail sorting within a General Mail Facility have necessitated improvements in equipment designed to transport said trays of letter mail and said trays of flats mail to, from and between sorting operations within a postal facility. Although similar needs for mechanized material handling exist in many other industries, the mechanization of the handling of trayed letter mail and trayed flats mail seems to be the most critical present need.

The recent improvements in letter mail and flats mail sorting equipment have also created the need for high-throughput, storing, buffering and sorting systems for lett r trays and for flats trays. The Postal Service's need for this type system is reviewed in the following paragraphs.

Letter Mail is typically subjected to a minimum of two sorting operations, sorting for delivery to the correct general

geographic region and sorting for delivery by a specific letter carrier. It has been determined that the sorting of letter mail for delivery can be accomplished more efficiently if the letter mail is barcoded with an identification related to the destination of the letter. As such, the Postal Service is endeavoring to increase the percentage of letter mail that is barcoded.

One means, currently being used, to increase the percent of mail being barcoded is to have large volume mailers pre-barcode their mail prior to mailing. Another method being used is to add the barcode to the letter by an Optical Character Reading(OCR) machine while it is being sorted within a postal facility. Additionally, and most recently, a method of Remote(off-site) Barcoding has begun to be implemented to further increase the percentage of mail which is barcoded.

As a result of this increased barcoding of letter mail, Delivery Bar Code Sorting(DBCS) machines have been purchased by the U.S. Postal Service, with the intention of sorting barcoded letters and placing the barcoded letters into letter trays according to the Letter Carrier's actual delivery sequence.

With the above situation in mind, four separate applications within the U.S. Postal Service have recently developed. These four applications are each discussed below under the topics: (A) In-Process Storage and Retrieval requirements, (B) DBCS Storage and Retrieval requirements, (C) DBCS/BCS Multi-Scheme Storage and Retrieval requirements and (D) Dispatch Storage and Retrieval requirements.

In-Process Storage and Retrieval Requirem nts

A recently implemented method of barcoding letter mail is known as Remote Bar Code Scanning(RBCS). Optical Character Recognition (OCR) machines have been used in recent years to read the addresses on letter mail and then to print a barcode on the letter mail. This new Remote Bar Code Scanning(RBCS) involves off-site personnel entering information to allow mail to be barcoded, which has been rejected by an Optical Character Recognition(OCR) machine, because the address on the piece of mail was found to be indecipherable by the OCR machine itself. Off-site personnel enter the barcode information by viewing an image of each piece of rejected letter mail on a CRT and then enter a code into a computer system which allows the letter mail to be barcoded during the next mail sorting operation. Letter mail which is barcoded by this method must be temporarily stored (buffered) while the off-site personnel enter the letters barcode information.

As a result of this newly developed method of remotely barcoding letters, trays containing letter mail being remotely barcoded must be buffered for a period of time. Currently, these trays of letter mail, waiting for remote barcoding, are loaded onto general purpose carts and placed in a holding area until the barcode information is entered.

DBCS Storage and Retrieval requirements

The secondary sorting of letter mail is typically comprised of one to four individual passes through various sorting equipment. Typically, mail is sorted by (1) general geographic r gion, then sorted by (2) zone, then sorted by (3)

carrier and finally sorted by d livery sequence. Currently letter carriers accomplish this last sort manually. This sorting is called Carrier Route Sequencing.

A machine known as a Delivery Bar Code Sorter(DBCS) has been developed as a mechanized means by which to Carrier Route Sequence barcoded letter mail. To accomplish this Carrier Route Sequencing the DBCS machine must process each letter two times. These two processes are known as "first pass sort" and "second pass sort". During the first pass sort, the letters for a group of mail carrier routes are collectively sorted and grouped such that all mail to be delivered to the first address of the routes is combined into one letter tray, all mail that is to be delivered to the second address of all routes is combined into a separate letter tray and so forth for each additional delivery address of the mail carrier routes. Each of these trays is given a unique identity, referencing it to the sequence of delivery on the set of routes. These trays must be buffered for a period of time prior to the second pass sort. To perform the second pass sort, these trays of letter mail must be delivered back to the DBCS machine according to the delivery sequence. The second pass sort then sorts the letters, already sorted by delivery address sequence, into trays identified by carrier route. The result is Carrier Route Sequenced mail.

As a result of the U.S. Postal Service's recent procurement of DBCS machines, there is an increased need to efficiently expedite the delivery, the take-away, the intermediate sorting, the re-delivery in a sp cific order and the buffering prior to dispatch, of the trays of letter mail

involved in two pass sorting.

Currently, trays of letter mail waiting for s cond pass sort are either loaded onto general purpose carts and placed in a holding area or loaded onto tray racks.

DBCS/BCS Multi-Scheme Staging and Retrieval requirements

At times, a Bar Code Sorter(BCS) or a Delivery Bar Code Sorter(DBCS) will be utilized to sort two or more independent sets of letter mail. When this occurs, the first pass sort is performed on the first set of letter mail. The first pass sort is then performed on each subsequent set of letter mail. After all sets of letter mail have had a first pass sort performed, each set of letter mail has the second pass sort performed.

Due to the increasing volume of barcoded letter mail, there is an increasing need to expedite the taking away, the intermediate sorting and the re-delivery, in a specific order, of the trays of letter mail involved in two pass sorting.

Currently, each set of trayed letter mail waiting for second pass sort is loaded onto a group of general purpose carts and placed in a specific holding area. These trays of mail are stored for a period of time. The group of carts for a set of letter mail is returned to the BCS or DBCS machine in a specific order at the time when the BCS or DBCS machine is ready to perform the second pass sort on the set of letter mail.

Dispatch Staging and Retrieval requirements

Trayed letter mail or trayed flats mail becomes available for shipment to other facilities or for distribution locally during a relatively short window of time each day.

There is an increasing need to temporarily store these trays of letter mail or flats mail as they become available, and to store them in a common area, until all trays of mail to be loaded onto the same truck are available.

Currently, trays of letter mail and flats mail are loaded onto general purpose carts near the location of the last operation performed. The general purpose carts are then manually transported to the shipping area.

Prior art workers have done much work in conjunction with mechanized letter sorting systems. Also, much work has been done with regard to conveyorized tray or carton handling. Other work has been done involving horizontal sorting carrousels or multi-tiered high-shelf storage and retrieval systems. An example is U.S. Patent No. 5,056,978 which relates to a high shelf system with a combination of reciprocating vertical lifts and reciprocating horizontal transfers. It appears to be an improvement over previous storage and retrieval systems where articles are stored on fixed shelves, opposing one-another about a center aisle. This system appears to employ independent reciprocating horizontal devices to perform the task of loading and unloading the storage shelves. This system also appears to store and retrieve individual articles or containers. In contrast to the present invention, this system is not designed to sort articles. The high shelf system does not include a vertical sorter of the type described

in the present invention. The high shelf system also does not employ the use of a series of conveyorized storage surfaces as in the present invention.

SUMMARY OF THE INVENTION

A typical embodiment of the present invention includes a vertically oriented sorter, hereinafter known as a lift conveyor, with a series of carriers to incrementally transport articles fully around the sorter in either direction so as to be capable of loading, unloading and sorting articles in and amongst a stack of conveyors, hereinafter known as buffer conveyors, or to transport the articles to, from or between input and output points of the system, such input and output points hereinafter known as lateral transfer conveyors. The lift conveyor utilizes at least one internally mounted pushing and extracting device for the unloading and loading of articles from and to the lift conveyor.

In accordance with the present invention, the lift conveyor contains a chain driven mechanism that allows for incremental or continuous movement in either a clockwise or counter-clockwise fashion. A number of carriers are attached along the length of the chain drive of the lift conveyor. The carriers are specially designed to allow a pushing device to discharge an article from the carrier. The carriers are also specially designed to allow a non-gripping extraction device to extend into the carrier to assist the adjacent buffer conveyor in transferring an article from a buffer conveyor to the corresponding position on the lift conveyor. The carrier mounting, in relation to the carrier guide track, causes the carrier to tilt at various positions in the travel of the lift conveyor, compensating for the inertia of the article being conveyed, thereby adding stability.

The carriers are attached to the chain drive of the lift conveyor at intervals dictated by the application. This carrier spacing is synchronized with the buffer conveyor spacing to allow alignment of multiple carriers and buffer conveyors simultaneously. The maximum allowable height of articles to be conveyed on a lift conveyor carrier is determined by the vertical spacing of the lift conveyor carriers, up to the maximum internal clearance of the lift conveyor structural members. The lift conveyor also contains a chain-slack take-up mechanism which does not affect the attitude of the carriers.

Pushing and extracting devices are used to transfer articles to and from the vertical sorters. The pushing and extracting devices each utilize pneumatic cylinders.

The extracting device extends as the lift conveyor carriers complete their motion. An important principle in the operation of the extracting device is that it lowers below the lift conveyor carrier load carrying surface as it becomes fully extended. Upon retracting, the extracting device raises to lift the leading edge of the article off of the lift conveyor carrier, causing the article to be simultaneously pulled by the extracting device and pushed by the buffer conveyor. The extracting device does not grip the article in its attempt to retrieve the article. The extractor is an assistance device to the buffer conveyor in transferring loads from a buffer conveyor to a carrier along the lift conveyor.

The pushing device is activated to transfer an article from the lift conveyor to either a buffer conveyor or to a lateral transfer conveyor. Each pusher is a pneumatically

operated reciprocating device, with guide bars, and is paired with an extracting device.

Although one version of the vertical sorter includes only one pushing and extracting device, which travels vertically to align itself with the buffer conveyor being loaded or unloaded, the high-throughput and principal version of the vertical sorter utilizes one pushing device and one extracting device for each tier of buffer conveyor.

The present system is also unique in that it utilizes conveyorized surfaces as storage extensions to the lift conveyor. These extensions are known as buffer conveyors. One set of buffer conveyors is comprised of a stack of conveyors, of a determined length and is associated with one specific lift conveyor. The length of a buffer conveyor allows the lift conveyor to hold a quantity of articles equal or greater than the number of articles held by one buffer conveyor. The vertical spacing of a stack of buffer conveyors is application dependant. Each buffer conveyor consists of a modular frame, one or more endless belts, and a drive linkage including a chain, sprocket and clutch for buffer conveyor travel toward the lift conveyor and a separate drive linkage including a chain, sprocket and clutch for buffer conveyor travel away from the lift conveyor. The endless belts of a buffer conveyor are made of a multiplicity of sections of flat track conveyor, including segments on regular intervals with protrusions on the conveying surface to insure articles stay positioned in the physical zones of the buffer conveyor. The buffer conveyors can operate either bi-directionally or unidirectionally, as determined by the application and as directed by the control

system.

The buffer conveyors may be of a variety of other typ s not described herein, including, but not limited to, belt top conveyor, roller conveyor or accumulating conveyor.

The buffer conveyors are driven by one of two methods described in the following paragraphs.

The first method, utilized in applications where continuous running of a buffer conveyor is required, uses one common drive mechanism for all buffer conveyor motion. Electrically interlocked clutch mechanisms allow each individual buffer conveyor to run toward the lift conveyor or away from the lift conveyor independent of all other buffer conveyors. The control system monitors all requests for buffer conveyor motion and processes the requests as required to maximize system throughput and minimize buffer conveyor drive motor loading.

The second method, utilized in applications where buffer conveyors only index the width of one article at a time as articles are stored or retrieved, uses an air cylinder in conjunction with a gripping jaw, on each conveyor, to index the conveyor toward the lift or away from the lift independent of all other buffer conveyors.

An important feature of the buffer conveyor conveying surface is that it is physically and logically sub-divided into individual buffering zones. A buffer conveyor zone is defined as that portion of the buffer conveyor surface that is required to store one uniquely identifiable article. The zones are physically divided, by means of mechanical divisions in the conveying surface and logically by means of electronic

registration of the conveyor position. The present invention allows for articles on more than one buffer conveyor to be simultaneously loaded or unloaded.

Another important feature of the present invention is that it may include one or more lateral transfer conveyors. These lateral transfer conveyors typically are located adjacent to the lift conveyor at a level equal to the bottom buffer conveyor or the top buffer conveyor. They may also be located at the level of any other buffer conveyor, as buffer conveyor spacing permits. When a total system contains more than one lift conveyor, the lateral transfer conveyors may span between lift conveyors. A lateral transfer conveyor contains a series of belt transfer devices to convey articles between the lateral transfer conveyor and the lift conveyor, and to convey articles between the lateral transfer conveyor and the adjacent buffer conveyor.

The present invention also includes a control system with appropriate electronic hardware and appropriate software to synchronize the motion of the lift conveyors, the pushing devices, the extracting devices, the buffer conveyors and the lateral transfer conveyors for the purpose of transferring articles to, from and within the system. The supervisory control system associated with an article storage and retrieval system has the means to control a multiplicity of lift conveyors, buffer conveyors and lateral transfer paths. The system contains one electrical panel for the combination of one lift conveyor and one stack of buffer conveyors. The system also includes a barcode scanning array for each lateral transfer conveyor to allow identification of articles entering

and exiting the system. The system further includes a programmable controller, with software, for control of lift conveyors, pushing and extracting devices, buffer conveyors and lateral transfer conveyors. The system additionally includes a computer, with software and a with a network interface port for communication to a host computer system.

The control system provides for programmable controller software to track and store the location of articles within the storage and retrieval system. The computer receives information from the programmable controller and stores the location of articles within the system. The computer system directs the programmable controller to cause lateral transfer conveyors, lift conveyors and buffer conveyors to store articles in specific locations.

An important feature of the control system, made possible by the systems unique mechanical configuration, is that the control system has the ability to direct a lift conveyor and one of its associated buffer conveyors to deliver all articles from the buffer conveyor to the lift conveyor and subsequently deliver the same articles back onto the same or different buffer conveyor in any pre-planned sequence thereby performing an internal sort of articles already stored. The control system has the ability to direct a lift conveyor and one of its associated buffer conveyors to deliver all articles from the buffer conveyor to the lift conveyor and subsequently deliver the same articles to a lateral transfer conveyor in any pre-planned sequence.

The control system additionally has the ability to graphically illustrate on its computer screen the physical

position of the articles on the lift conveyors and the buffer conveyors. The control system further has the ability to present textually on its computer screen the identification of a group of articles by touching the articles graphical representation of the articles on the computer screen.

The control system further includes an optical shaft encoder to track the position and movement of the lift conveyor. A sensor on the lift conveyor located at the top of one lift path and a sensor on the lift conveyor located at the bottom of the same lift path are used to insure correct lift conveyor position.

Additionally a photoelectric array mounted at the top of one lift path is aligned with a reflective array mounted at th bottom of the same lift path such that the photoelectric array is interrupted as articles are transferred onto and off of the lift conveyor and that the photoelectric array remains uninterrupted otherwise.

The various features of novelty which characterize the present invention are pointed out particularity in the claims annexed to and forming a part of this disclosure. For a better understanding of the invention, its advantages and specific objectives attained by its use, reference should be made to the drawing and descriptive matter in which there is illustrated and described a preferred embodiment of the invention.

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1A-1B is a longitudinal side view of an indexing, bi-directional vertical sorter with an arrangement of buffer conveyors.

FIG. 2A-2B is a top view of the vertical sorter and buffer conveyor arrangement depicted in FIG. 1.

FIG. 3 is a top view drawing of a lateral transfer conveyor with an arrangement of lift conveyors and buffer conveyors.

FIG. 4A-4B is an isometric view of a staging, buffering and sorting system consisting of a series of vertical sorters, buffer conveyors and lateral transport conveyors.

FIG. 5 is a side view of an indexing, bi-directional vertical sorter, known as a lift conveyor.

FIG. 6 is a side view of a carrier utilized in the lift conveyor.

FIG. 7 is a front view of a carrier utilized in the lift conveyor.

FIG. 8 is a top view of a carrier utilized in the lift conveyor.

FIG. 9 is a side view of a pushing device mounted to an extracting device as utilized in the lift conveyor.

FIG. 10 is a front view of a pushing device mounted to an extracting device as utilized in the lift conveyor.

FIG. 11 is a top view of a pushing device utilized in the lift conveyor.

FIG. 12 is a top view of an extracting device utilized in the

lift conveyor.

FIG. 13 is a end view of a fragment of a flat track style conveyor utilized as a buffer conveyor.

FIG. 14 is a side view of a fragment of a flat track style conveyor utilized as a buffer conveyor.

FIG. 15 is a top view of a fragment of a flat track style conveyor utilized as a buffer conveyor.

FIG. 16 is a fragment of a side view of a common conveyor drive mechanism utilized for buffer conveyors.

FIG. 17 is a plan view of an air cylinder drive utilized to drive a buffer conveyor.

FIG. 18 is a side view of a carrier linkage assembly.

FIG. 19 is a side view of a chain slack take-up mechanism.

FIG. 20 is a flow diagram of an article delivery to a buffer conveyor.

FIG. 21 is a flow diagram of an article extraction from a buffer conveyor.

FIG. 22 is a flow diagram of an internal sort of articles on a buffer conveyor utilizing a lift conveyor as a sorter.

DESCRIPTION OF THE PREFERRED EMBODIMENT

For the purpose of promoting an understanding of the principles of the invention, reference will now be made to the embodiment illustrated in the drawings and specific language will be used to describe the same. It will nevertheless be understood that no limitation of the scope of the invention is thereby intended, such alterations and further modifications in the illustrated device, and such further applications of the principles of the invention as illustrated therein being contemplated as would normally occur to one skilled in the art to which the invention relates.

FIGS. 1 to 4 of the drawing show an indexing, bi-directional vertical sorter inclusive of an arrangement of buffer conveyors 1, which is comprised of a vertically oriented sorter 2 herein referred to as a lift conveyor, a stack of conveying surfaces 3 herein referred to as buffer conveyors, a control system 5 with electrical enclosures and optionally one or more lateral transfer paths 4 herein referred to as lateral transfer conveyors. A multiplicity of systems as shown in FIGS. 1 and 2 may be arranged as shown in FIG. 3 or 4 utilizing common lateral transfer conveyors 4 and electronically interlocked control systems 5.

Articles are scanned by bar code scanning array 6 (FIG. 2) as they enter the system by means of a lateral transfer conveyor 4. The lateral transfer conveyor 4 conveys articles in position for delivery to an adjacent lift conv yor 2 or an adjacent buffer conveyor 3 as directed by the control system 5. When the article is directed to a buffer conveyor 3, other than

the adjacent buffer conveyor 3, the lift conveyor 2 stops, if not already stopped, a belt transfer device 7 (FIG. 3), integral to the lateral transfer conveyor 4, rises while an extracting device 9 (FIG. 5) extends into the adjacent, non-moving lift conveyor carrier 8. The belt transfer device 7 then drives the article toward and onto the lift conveyor carrier 8 with the assistance of the now retracting extracting device 9 (FIGS. 5, 9, 10 and 12). Subsequently, lift conveyor 2 engages, driving the lift conveyor carrier 8 along a lift path until such time as the lift conveyor carrier 8 is aligned with the buffer conveyor at the appropriate level. Upon completion of lift conveyor motion, the lift conveyor carrier 8, containing the article being stored, is aligned with a buffer conveyor at the desired level such that a pusher device 10 (FIGS. 5, 9, 10 and 11) can extend into lift conveyor carrier 8 and toward the article resting on the lift conveyor carrier 8, pushing the article onto the adjacent buffer conveyor. As a buffer conveyor entry/exit sensor 11 (FIG. 1) is interrupted by the article being conveyed, a buffer conveyor clutch 12 (FIG. 1) engages, driving the article fully onto the buffer conveyor into a position just clear of the buffer conveyor entry/exit sensor 11. As the pusher device 10 becomes fully extended, it receives a pusher device retract signal and returns to a fully retracted position, clear of the lift conveyor 2 and the lift conveyor carrier 8.

Articles being retrieved from the system are conveyed out of the system from the appropriate buffer conveyor 3, to a lateral transfer conveyor 4 by means of the lift conveyor 2. Articles are scanned by bar code scanning array 6 as they exit

the system. In detail, upon receipt of a command from the control system 5 to retrieve an article, the lift conveyor 2 stops, if not already stopped, and the extracting device 9 extends into the lift conveyor carrier 8. The buffer conveyor, containing the article to be retrieved, indexes one zone toward the lift conveyor 2. When the buffer conveyor has indexed the article approximately one half way onto the lift conveyor carrier 8, the extracting device 9 retracts to assist the buffer conveyor in transferring the article to the adjacent lift conveyor carrier 8. If the desired article was not located at the buffer conveyor zone adjacent to the lift conveyor, the lift conveyor 2 indexes to position the next available lift conveyor carrier in line with the buffer conveyor containing the desired article. The steps above are repeated to retrieve each subsequent article from the buffer conveyor until the desired article is transferred onto the lift conveyor 2. The lift conveyor 2 then engages, this time, to convey the article to a position in-line with the lateral transfer conveyor 4 such that a pusher device 10 can extend into the lift conveyor carrier 8 containing the article being retrieved. When space becomes available on the lateral transfer conveyor 4, the adjacent pusher device 10 activates, pushing the article onto the lateral transfer conveyor unassisted by the belt transfer device 7. As the pusher device 10 becomes fully extended, it receives a pusher device retract signal and returns to a fully retracted position, clear of the lift conveyor 2 and the lift conveyor carrier 8. All articles remaining on the lift conveyor, if any, are returned to the buffer conveyor, by previously described means, such that they

are in their original order, prior to the retrieval of the desired article.

The system is also capable of retrieving articles from one buffer conveyor and by use of the lift conveyor 2, an extracting device 9 and a pushing device 10, return the article to a different buffer conveyor. Additionally, the system can retrieve all articles from one buffer conveyor onto the lift conveyor 2 and subsequently deliver them to the same or different buffer conveyor, as directed by the control system 5, in a different order as defined by a table contained in the memory of the control system.

FIGS. 5 to 12 in the drawing show the details, in combination and individually, of a lift conveyor 2, of lift conveyor carriers 8, pushing devices 10 and extracting devices 9. The significant features of each of the individual devices is herein described prior to the detailed description of the lift conveyor drive and guide track mechanisms.

Referring to FIGS. 6, 7 and 8, each lift conveyor carrier 8 includes: two extractor cut-outs 14 to allow the extracting device to extend into the area of the lift conveyor carrier 8, one pusher cut-out 15 to allow the pushing device to extend into the area of the lift conveyor carrier 8, four carrier drive attachment points 16, two carrier guide attachment points 17, a carrier structural member 18 to provide rigidity across the various cut-outs of the lift conveyor carrier 8, two angled side guards 19 and eight rounded leading edges 20 to prevent damage to extracted articles and reduce the likelihood of a jam. An alternate guidance track arrangement can be utilized

which allows for four carrier guide attachment points 17 and two carrier drive attachment points 16.

Referring to FIGS. 9, 10 and 11, each pushing device 10 includes: one dual acting cushioned air cylinder 21 secured in a frame, one low friction surfaced pusher head 22 including a pusher head cut-out 23 for lift conveyor carrier 8 clearance, two pusher guide bars 24 and four pusher guide sleeves 25 secured in a frame. Each extracting device 9 includes: one dual acting cushioned air cylinder 21 secured in a frame, two extracting bars 26 each including a high friction portion in the area of article contact, a cylinder shaft attachment 27 on the extremity of the cushioned air cylinder 21 shaft which allows the extractor tie brace 28 to rotate freely within the cylinder shaft attachment 27, two extractor guide rollers 29 mounted on the extracting bars 26 and riding within two extractor guide tracks 30 which are formed such that the forward guide track portion 31 of the extractor guide tracks 30 is angled causing the extracting device 9 to lower the extracting bars 26 below the lift conveyor carrier 8 load carrying surface.

The lift conveyor 2 (FIG. 5) contains a plurality of lift conveyor carriers 8 which can be spaced equally about the full length of the lift conveyor 2. The lift conveyor carriers 8 assume an inertia compensating attitude as they travel onto, across and off of the horizontally traversing portions 33 of the lift conveyor 2 while otherwise assuming a slightly inclined attitude to improve stability of articles being conveyed vertically along the lift paths.

FIG. 18 in the drawing shows lift conveyor carriers 8

attached to the lift conveyor drive chain 35 using a carrier attachment assembly 34 designed to extend the effective attachment point of the lift conveyor carriers 8 beyond the path of the lift conveyor drive chain 35 thereby increasing the radius of the lift conveyor carrier path at the transitions between the lift paths and the traversing paths of the lift conveyor carriers 8 and increasing the clearance between carriers at said transitions. This carrier attachment assembly is constructed using two carrier drive linkage bars 38, each mounted on one end to a point along the lift conveyor drive chain 35 and on the other end to a common point on the lift conveyor carrier 8 such that the two carrier drive linkage bars 38 articulate at the point of attachment to the carrier as they span the transitions between the vertical paths and the horizontal traversing paths of the lift conveyor 2. Additionally the carrier attachment assembly includes a carrier linkage shaft 39, a carrier guide linkage bar 40 and a carrier guide roller 41 which are at a fixed angle with respect to the carrier. The carrier drive linkage bar 40 rotates about the carrier linkage shaft 39 as the lift conveyor 2 drives the carrier at the transitions between the lift paths and the traversing paths of the lift conveyor 2.

The chain slack take-up mechanism 43 (FIG. 19) is integral to the lift conveyor frame 43 and 44 in that the frame is divided into a lower frame portion 43 containing the drive train with the lower drive sprockets 36, pushing devices 10, extracting devices 9, the controls and the vertical and lower traversing portion of the carrier guide track 45, and an upper frame portion 44 containing the upper drive sprockets 36 and

the upper traversing carrier guide track. The chain slack take-up mechanism includes a take-up spindle 46 right hand threaded on one end, a left hand threaded on the other end and with a drive gear about its center. Each of the four take-up spindles 46 can be attached to a common drive chain and driven either manually or automatically to adjust the chain tension, thus insuring equal chain tension at each of the four chain tension points.

The electrical control enclosure containing control system 5 is mounted to the lower frame portion 43 of the lift conveyor adjacent to the lift conveyor drive motor 47.

FIGS. 13 to 16 of the drawing show a buffer conveyor 3 assembly and details comprised of a buffer conveyor frame 48, a buffer conveyor endless belt 49 and a buffer conveyor drive mechanism 50. The buffer conveyor frame 48 includes; buffer conveyor side-frames 51 of formed or extruded material, which side-frame includes integral conveyor mounting channels 52 and article guidance side guards 53 to guide articles along the buffer conveyors 8, buffer conveyor cross braces 54 and buffer conveyor endless belt guide tracks 55 to captivate the endless belt. The conveyor mounting channels 52 allow the buffer conveyors to be fixed, at various vertical spacings, in a conveyor mounting structure attached to the building.

FIG. 16 shows one method of driving the buffer conveyors. This method includes; a multiplicity of buffer conveyor drive chains 57, a buffer conveyor drive motor 58 with gear reducer including an output drive train arrangement utilizing two primary drive sprockets 59 rotating in opposite directions connected to the same primary drive chain 60 such that one

arrangement of buffer conveyor drive chains 57 is used to drive articles toward the lift conveyor 2 and the other arrangement of buffer conveyor drive chains 57 is used to drive articles away from the lift conveyor 2, a series of buffer conveyor clutches 12 with brakes to engage either buffer conveyor drive chain 57 such that either buffer conveyor drive chain 57 can drive each buffer conveyor independently.

FIG. 17 shows another method of driving buffer conveyors. This method includes an independent drive mechanism for each buffer conveyor comprised of; a single ended, double acting buffer conveyor drive cylinder 61 used to push or to pull a buffer conveyor slide bar 63 as a buffer conveyor drive engage air cylinder 62 causes the buffer conveyor slide bar 63 to engage the conveyor endless belt 49. This method of driving buffer conveyors allows for single article entry or exit from or to the lift conveyor 2 with each stroke of the conveyor drive cylinder. The conveyor drive engage cylinder 62 acts independently of the conveyor drive cylinder 61 enabling buffer conveyor motion toward the lift conveyor 2 or buffer conveyor motion away from the lift conveyor 2 using the same conveyor drive cylinder 61.

The buffer conveyor endless belt 49 includes; a plurality of non-flexible belt segments 64 coupled end to end by means of clevis pins to form an flexible endless belt 49, a plurality of non-flexible dividing belt segments 66, located at specific intervals, each with a protrusion on its conveying surface for the purpose of registering article position with respect to buffer conveyor position, a plurality of drive brackets 66, located at specific intervals, each with a protrusion under its

conveying surface for the purpose of registering buffer conveyor position with respect to lift conveyor 2 position.

FIGS. 20, 21 and 22 in the drawing show flow diagrams depicting the sequence of operation to store an article, to extract an article and to sort a series of articles on the lift conveyor. The control system 5 initiating this motion includes; a series of electrical panels containing control hardware for lift conveyors 2, buffer conveyors 3 and lateral transfer conveyors 4, a barcode scanning array 6 for each lateral transfer conveyor 4 to allow the system to identify articles, a programmable controller, with software, for control of lift conveyors 2, buffer conveyors 3 and lateral transf r conveyors 4, a computer, with software, for supervisory control of the system, and a network interface port, on the computer, for communication to a host computer system.

The programmable controller software tracks and stores the location of articles within the storage and retrieval system. Additionally the computer stores the location of articles within the storage and retrieval system. The control system 5 additionally has the ability to direct lateral transfer conveyors 4, lift conveyors 2 and buffer conveyors 3 to store articles in specific locations. The control system 5 further has the ability to direct a lift conveyor 2 and one of its associated buffer conveyors to deliver all articles from a buffer conveyor to the lift conveyor 2 and subsequently deliver the same articles back onto the same or a different buffer conveyor in any pre-planned sequence. The control system 5 further has the ability to direct a lift conveyor 2 and one of its associated buffer conveyors to deliver all articles from

the buffer conveyor to the lift conveyor 2 and subsequently deliver the same articles to a lateral transfer conveyor 4 in any pre-planned sequence. The control system also has the ability to graphically illustrate on the computer screen the physical position of the articles on the lift conveyors and the buffer conveyors. The control system 5 further has the ability to present textually on the computer screen the identification of a group of articles by touching the article's graphical representation on the computer screen. The control system includes an incremental optical shaft encoder to track the position and movement of the lift conveyor 2. A sensor 68 on the lift conveyor 2 located at the top of one lift path and a sensor 68 on the lift conveyor 2 located at the bottom of the same lift path are used to insure correct lift conveyor position and to detect lift conveyor chain stretch. The system automatically compensates for the change in carrier stopping position due to chain stretch by monitoring the timing and sequence with which these sensors 68, one located at the top of one lift path and one located at the bottom of the lift path, detect passing lift conveyor carriers. The control system 5 uses a photoelectric sensing array 69 for collision avoidance mounted at the top of one lift path aligned with a reflective array 70 mounted at the bottom of the same lift path, such that the photoelectric array 69 is interrupted as articles are transferred onto and off of the lift conveyor and that the photoelectric array 69 remains uninterrupted otherwise. Movement of the lift conveyor is electrically inhibited when this photoelectric array is interrupted.

While the invention has been illustrated and described in

detail in the drawings and foregoing description, the same is to be considered as illustrative and not restrictive in character, it being understood that only the preferred embodiment has been shown and described and that all changes and modifications that come within the spirit of the invention are desired to be protected.

THE INVENTION CLAIMED IS:

1. In an article storage and retrieval system having means for receiving articles to be stored and for delivering articles which have been stored therein, the combination comprising:

a lift conveyor having two generally parallel horizontally-spaced paths and having lateral transfer paths between the lift paths, for simultaneously moving articles up one of the lift paths and down the other of the lift paths and laterally between upper ends of the lift paths and between lower ends of the lift paths; and

a plurality of vertically spaced buffer conveyors extending horizontally from at least one of the lift paths to receive articles from the lift conveyor.

2. The combination of claim 1 and wherein:

the lift conveyor has a reversible driver for driving the articles along the lift conveyor in one operating direction and then driving the articles along the lift conveyor in an opposite operating direction.

3. The combination of claim 1 and wherein:

the buffer conveyors have reversible drivers for driving articles horizontally along them away from and toward the lift conveyors; and

each buffer conveyor includes a modular frame; and

each buffer conveyor includes at least one endless belt.

4. The combination of claim 3 and wherein:

the drivers include two drive sprockets for each buffer

conveyor;

there are two drive chains;

there is a buffer conveyor drive motor driving one of the drive chains in one direction and simultaneously driving the other of the drive chains in the opposite direction;

there are two selectively operable clutches associated with each drive sprocket, one of the two clutches being associated with one of the drive chains and the other of the two clutches being associated with the other of the drive chains whereby, upon engagement of one of the clutches the buffer conveyor belt associated through its drive sprocket with the one clutch is driven away from the lift conveyor and, upon engagement of the other of the clutches the buffer conveyor belt associated through its drive sprocket with the other of the clutches is driven toward the lift conveyor.

5. The combination of claim 3 and wherein:

the drivers include an air cylinder for conveyor motion;

the drivers include a drive engaging mechanism, which when engaged allows the air cylinder used for conveyor motion to cause conveyor motion in either of two directions dependant upon the initial position of the cylinder used for conveyor motion.

6. The combination of claim 1 and further comprising:

extraction devices associated with the lift conveyor and operable, when actuated, to facilitate removal of articles from the buffer conveyors into at least one of the lift paths of the lift conveyor.

7. The combination of claim 6 and wherein:

the extraction devices are constructed and arranged to

move articles without gripping the articles.

8. The combination of claim 7 and further comprising:

pushing devices associated with the lift conveyor and operable, when activated, to push articles from at least one of the lift paths onto the buffer conveyors.

9. The combination of claim 8 wherein:

each extraction device includes a pneumatic cylinder;

each pushing device includes a pneumatic cylinder.

10. The combination of claim 1 and wherein the lift conveyor includes:

article carriers guided along the lift paths and transfer paths and having a normal carriage attitude on the lift paths and having an inertia compensating attitude on the transfer paths.

11. The combination of claim 10 and wherein the lift conveyor includes:

guide tracks;

carrier mounts associated with the guide tracks and connected to the carriers;

the guide tracks being arranged on the transfer paths to cause the carrier mounts to tilt the carriers as they move from the lift paths to the transfer paths, as they move along the transfer paths and as they move from the transfer paths to the lift paths.

12. The combination of claim 11 and wherein:

the carriers are mounted at intervals along the path of the lift conveyor such that a multiplicity of carriers are simultaneously aligned with a plurality of buffer conveyors.

13. The combination of claim 3 and wherein the endless

belt of each buffer conveyor includes:

a plurality of non-flexible belt segments coupled end to end to form an endless flexible belt; and including

additional non-flexible belt segments located at specific intervals, each with a protrusion on its conveying surface for the purpose of registering article position with respect to buffer conveyor position; and also including

additional non-flexible belt segments being located at specific intervals, each with a protrusion under its conveying surface for the purpose of registering buffer conveyor position with respect to lift conveyor position.

14. The combination of claim 3 and wherein each buffer conveyor includes:

a side frame with integral side guards to guide articles along the buffer conveyors; and the combination further comprises an endless belt guidance mechanism including an extrusion to captivate the endless belt during its full length of horizontal travel.

15. The combination of claim 1 and wherein the conveyors are constructed and arranged such that:

the quantity of articles which can be simultaneously conveyed by the lift conveyor equals or exceeds the quantity of articles which can be simultaneously conveyed by one buffer conveyor.

16. The combination of claim 1 and wherein there is a control system having means to control a multiplicity of lift conveyors, buffer conveyors and lateral transfer paths, comprising:

a series of electrical panels containing control hardware

for lift conveyors, buffer conveyors and lateral transfer conveyors;

a barcode scanning array for each lateral transfer path to allow the system to identify articles;

a programmable controller, with software, for control of lift conveyors, buffer conveyors and lateral transfer conveyors;

a computer, with software, for supervisory control of the system;

a network interface port for communication to a host computer system.

17. The combination of claim 16 and wherein:

the programmable controller software tracks and stores the location of articles within the storage and retrieval system.

18. The combination of claim 16 and wherein:

the computer tracks and stores the location of articles within the storage and retrieval system.

19. The combination of claim 16 and wherein the computer software includes:

the ability to direct lateral transfer conveyors, lift conveyors and buffer conveyors to store articles in specific locations;

the ability to direct a lift conveyor and one of its associated buffer conveyors to deliver all articles from the buffer conveyor to the lift conveyor and subsequently deliver the same articles back onto the same or a different buffer conveyor in any pre-planned sequence;

the ability to direct a lift conveyor and one of its associated buffer conveyors to deliver all articles from the

buffer conveyor to the lift conveyor and subsequently deliver the same articles to a lateral transfer conveyor in any pre-planned sequence.

20. The combination of claim 16 and wherein the computer software includes:

the ability to graphically illustrate on the computer screen the physical position of the articles on the lift conveyors and the buffer conveyors;

the ability to present textually on the computer screen the identification of a group of articles by touching the articles graphical representation on the computer screen.

21. The combination of claim 16 and wherein:

an incremental optical shaft encoder is used to track the position and movement of the lift conveyor;

a sensor on the lift conveyor located at the top of one lift path and a sensor on the lift conveyor located at the bottom of the same lift path are used to insure correct lift conveyor position.

22. The combination of claim 16 and wherein a lift conveyor jam detection circuit includes:

a photoelectric array mounted at the top of one lift path is aligned with a reflective array mounted at the bottom of the same lift path such that the photoelectric array is interrupted as articles are transferred onto and off of the lift conveyor and that the photoelectric array remains uninterrupted otherwise.

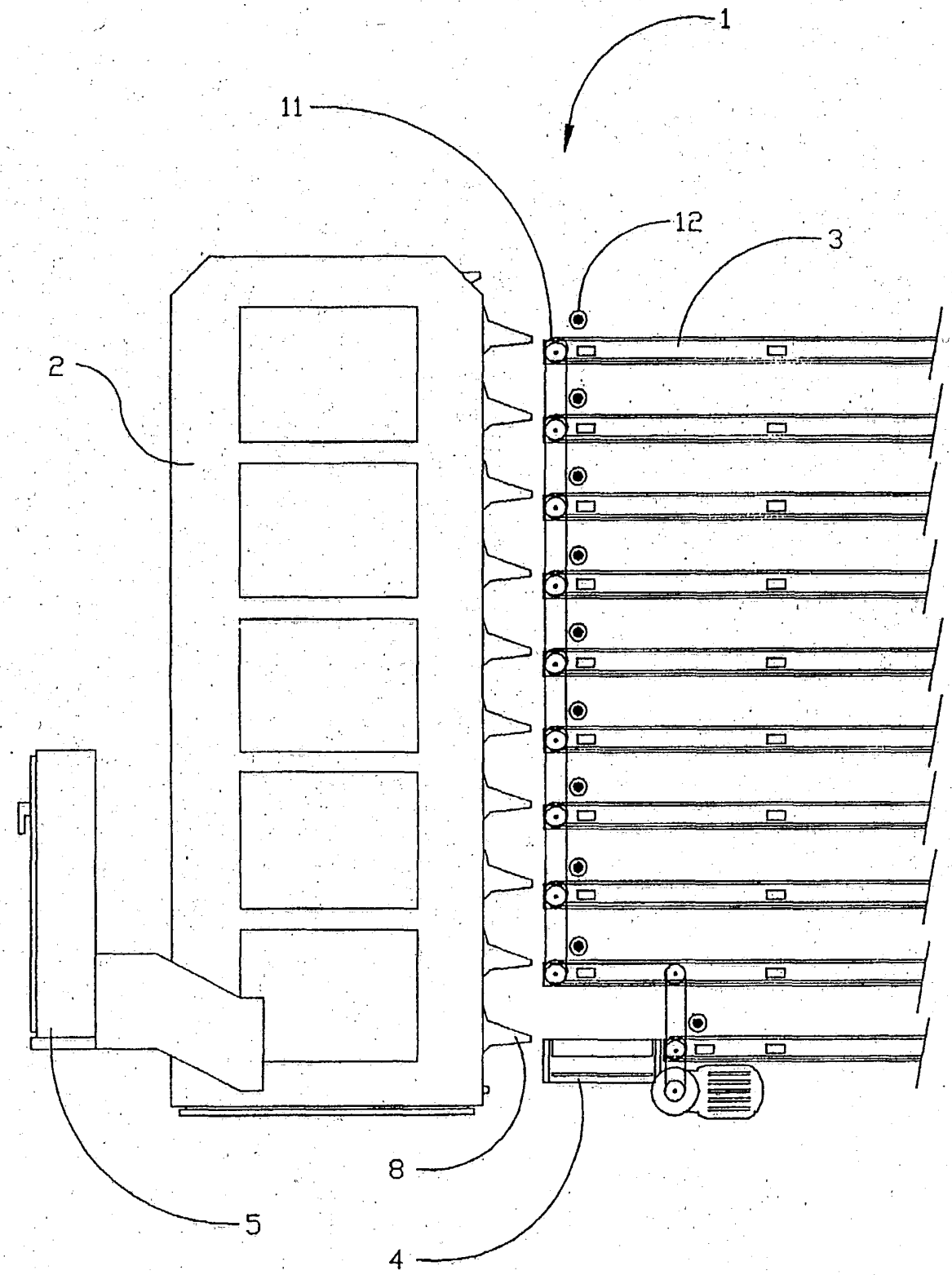

FIG. 1A

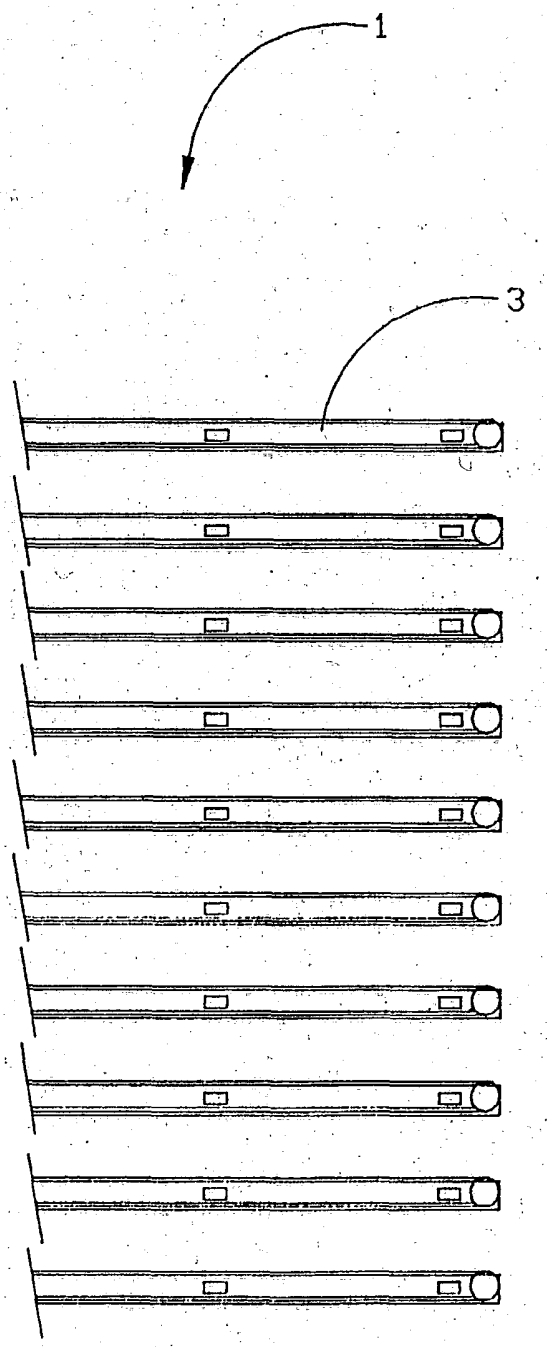

FIG. 1B

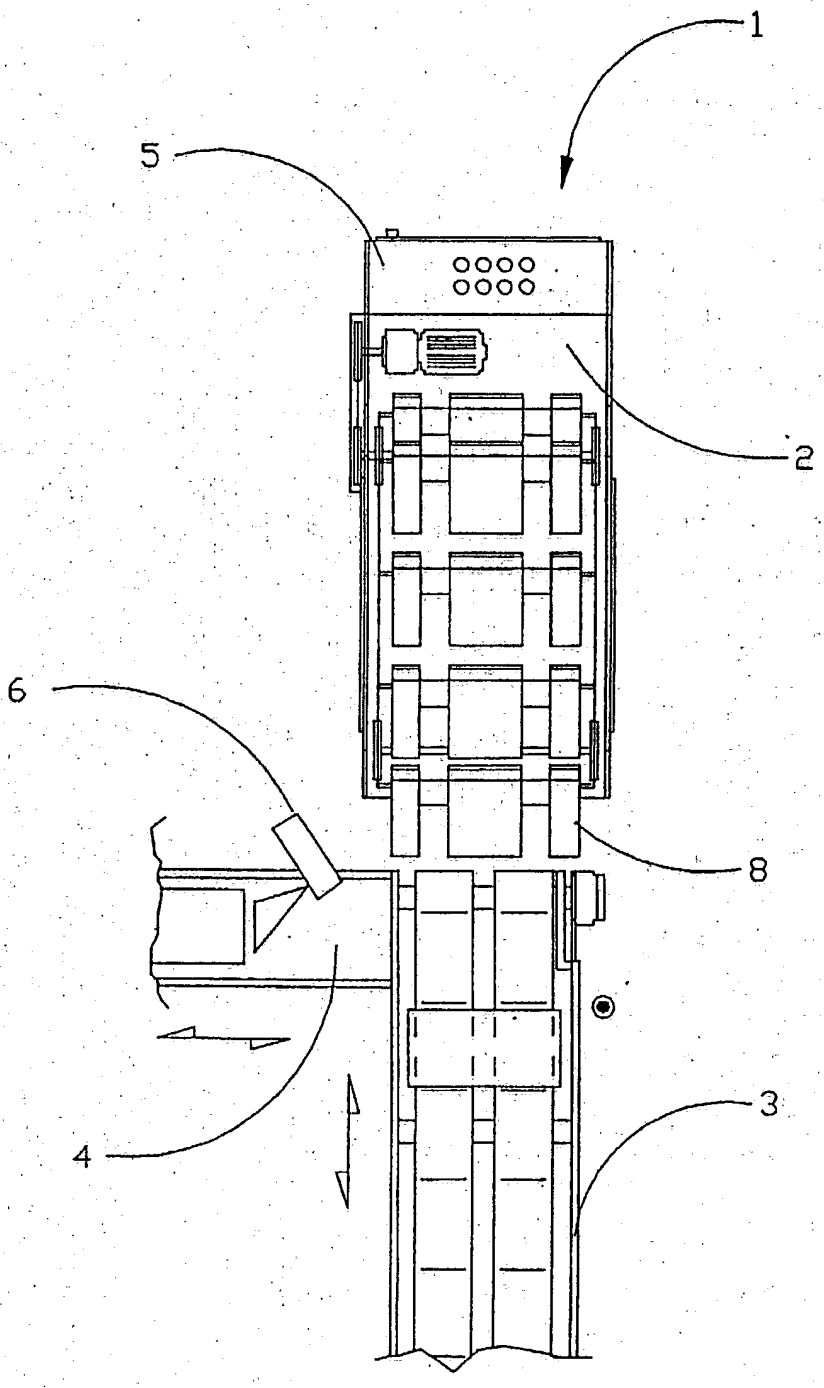

FIG. 2A

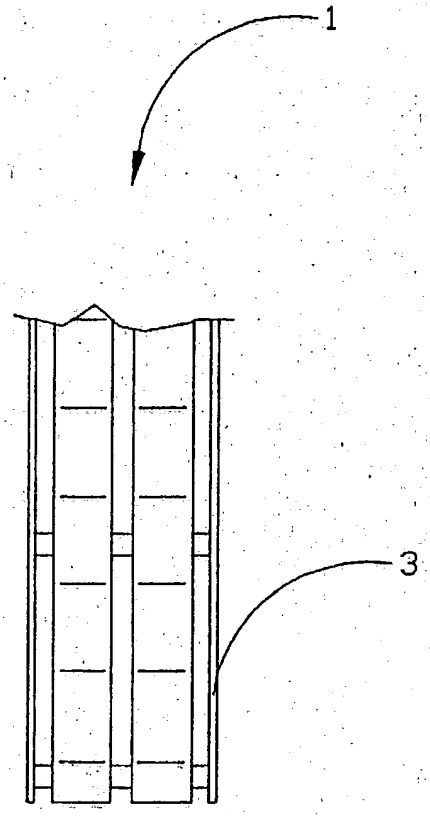

FIG. 2B

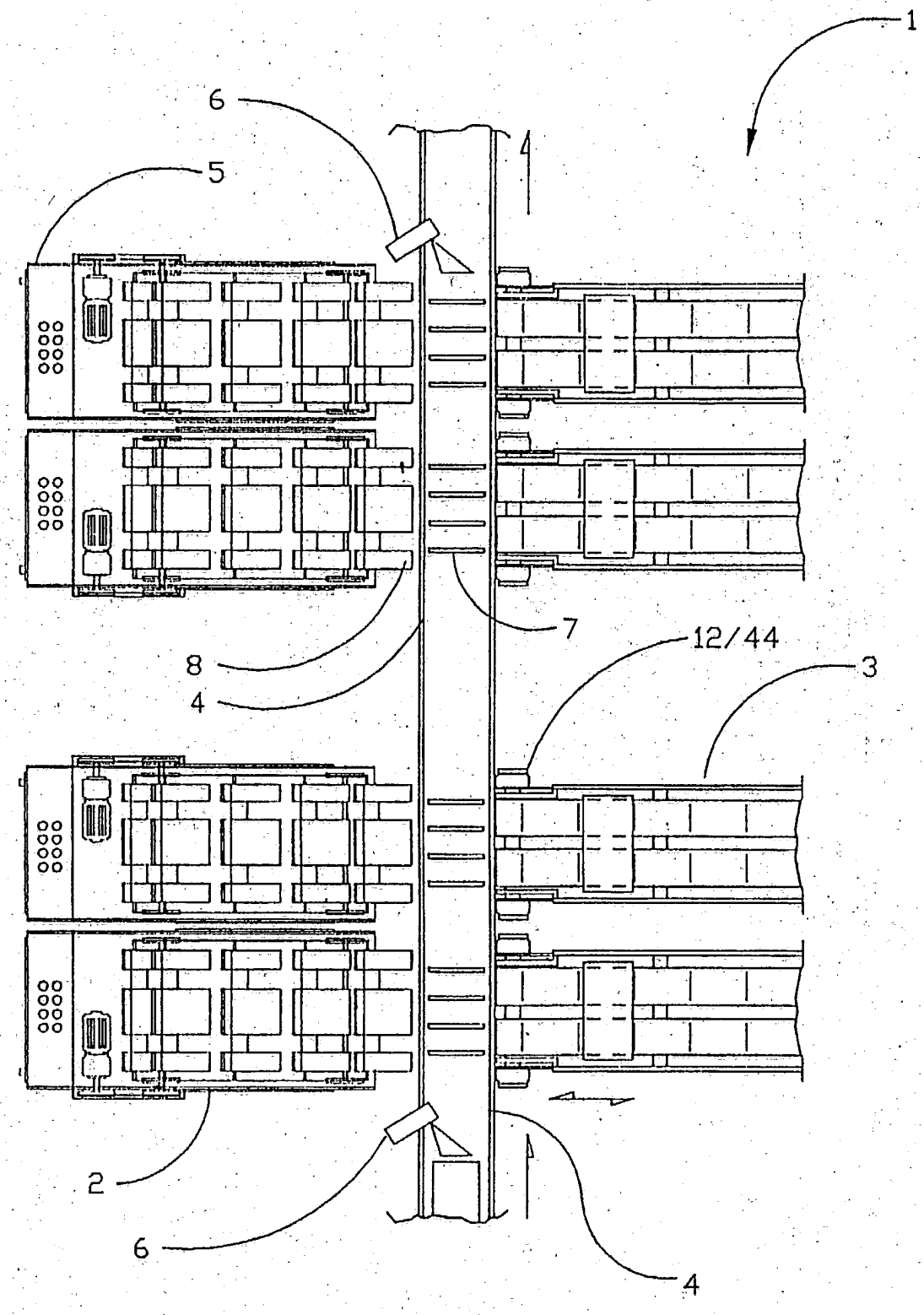

FIG. 3

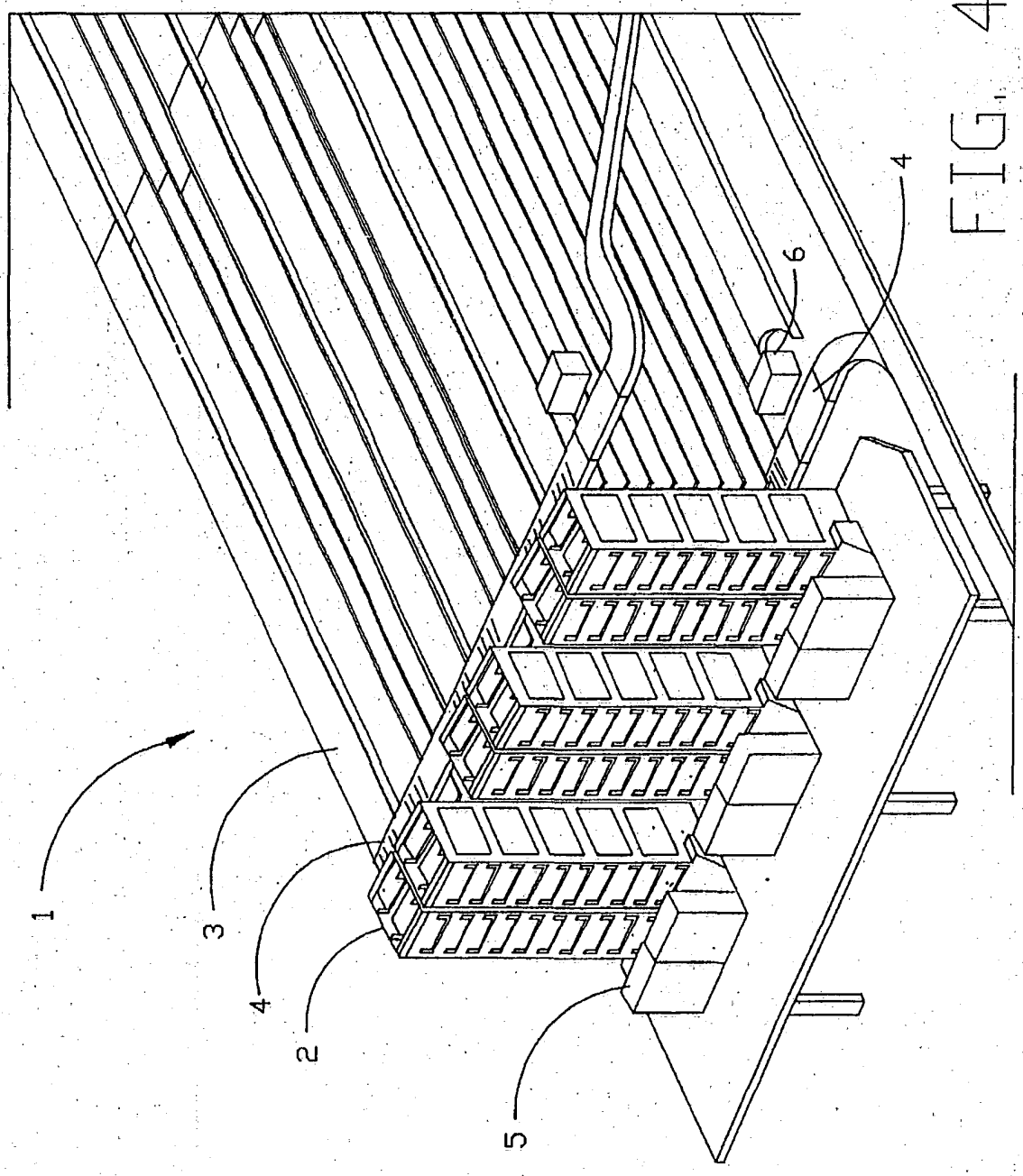

FIG. 4A

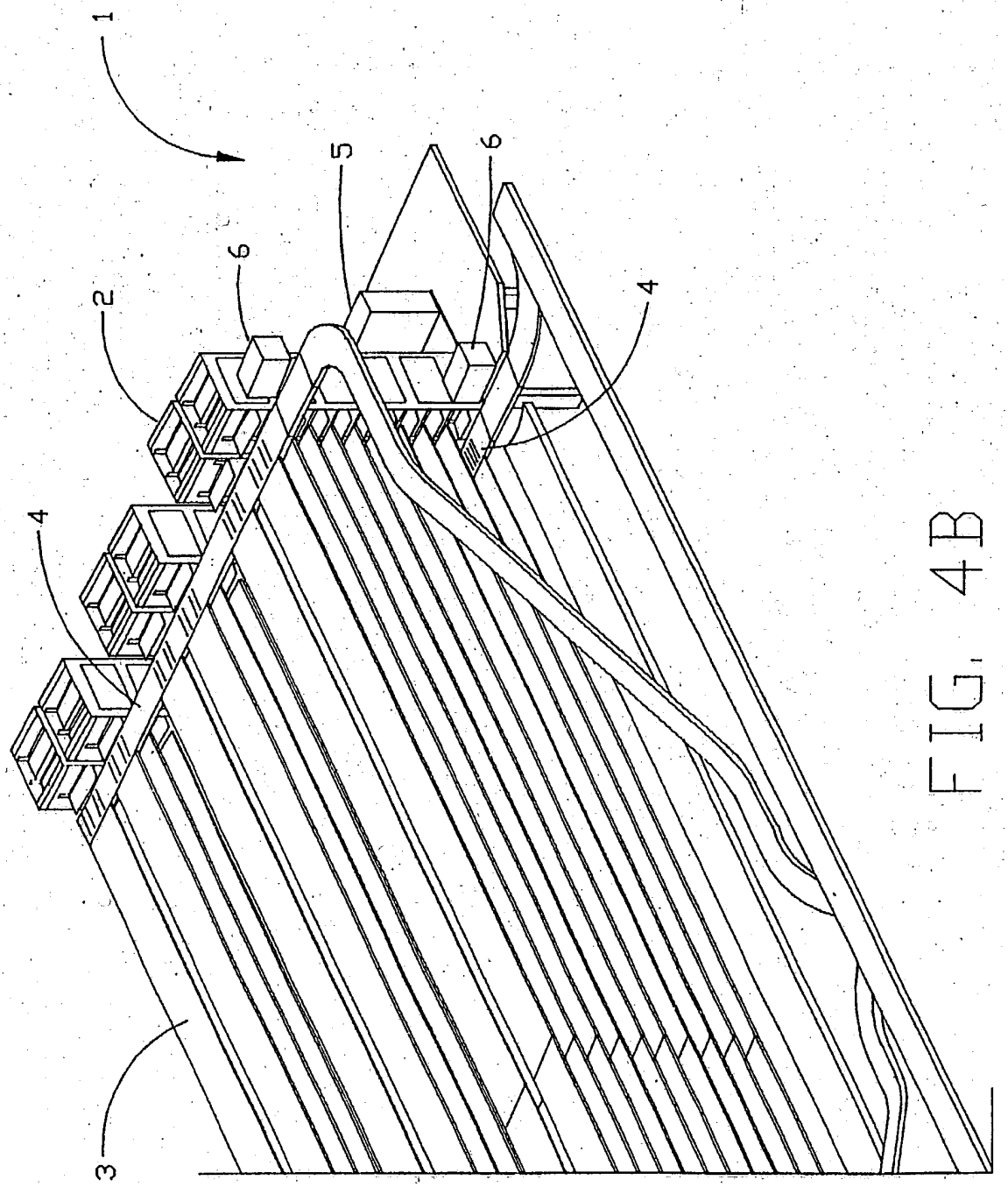

FIG. 4B

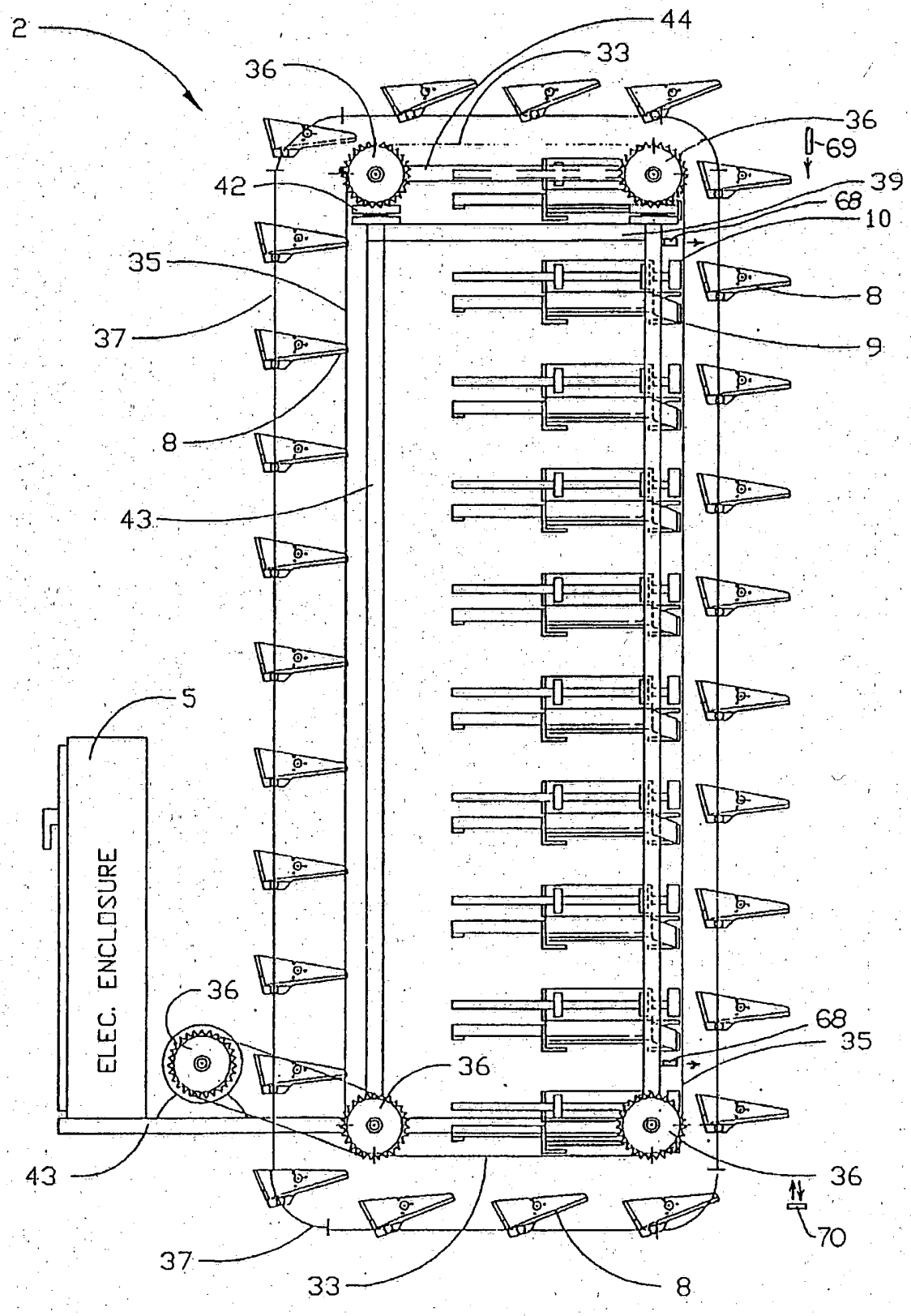
2
44
33
36
36
69
42
39
68
10
35
8
37
9
8
43
5
ELEC. ENCLOSURE
36
68
35
36
43
36
70
37
33
8

FIG. 5

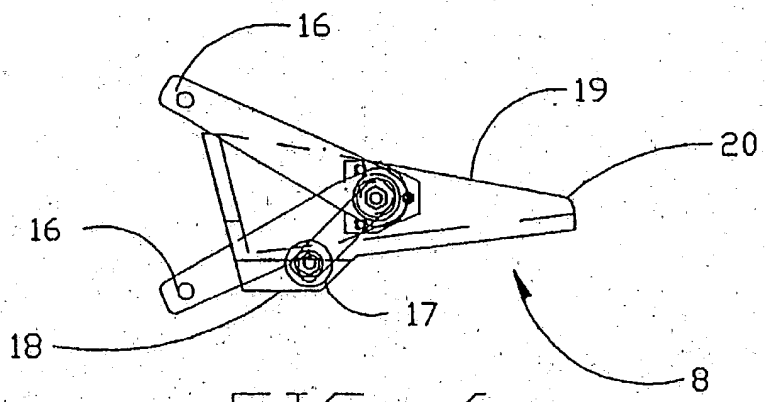

FIG. 6

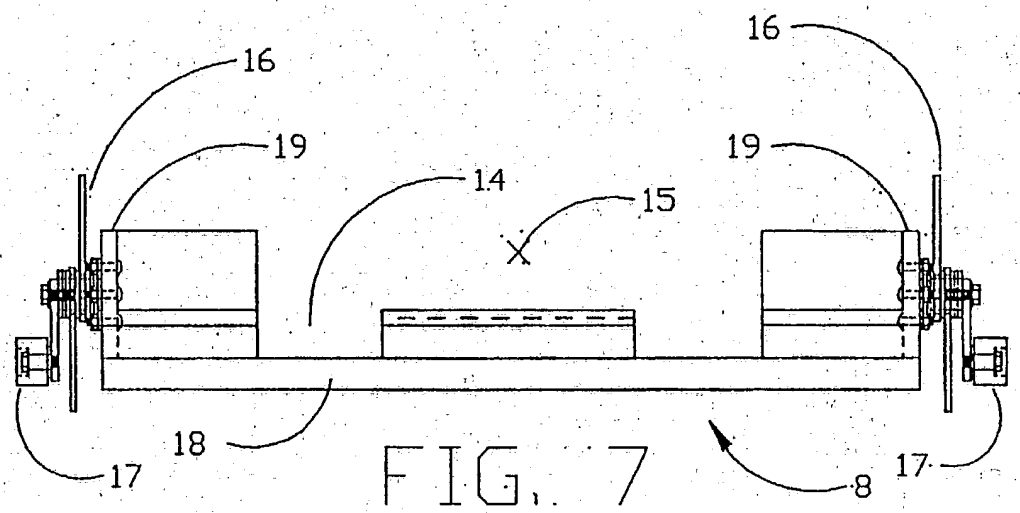

FIG. 7

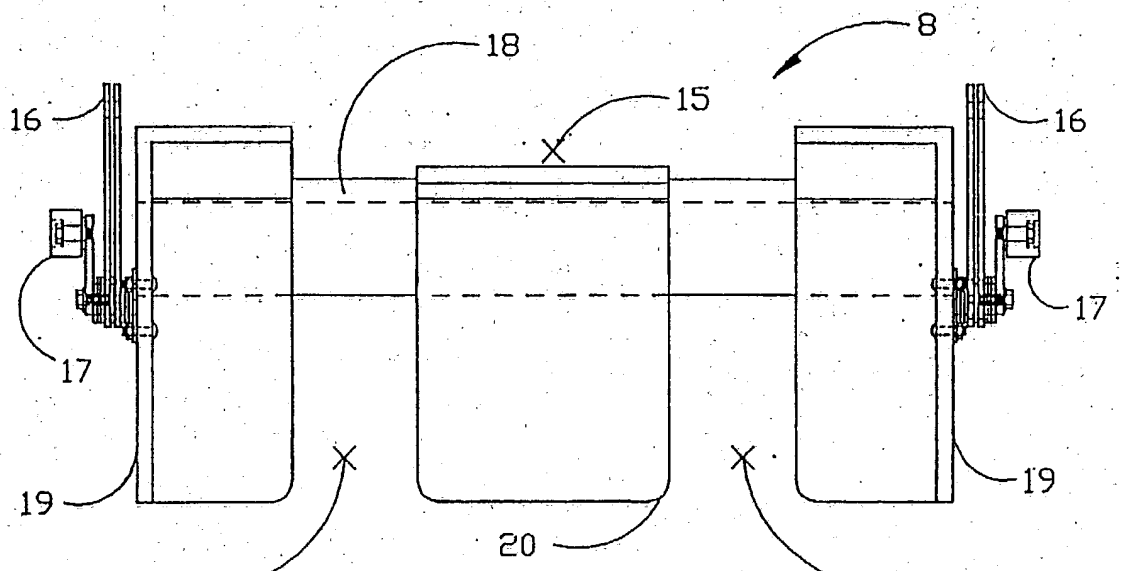

FIG. 8

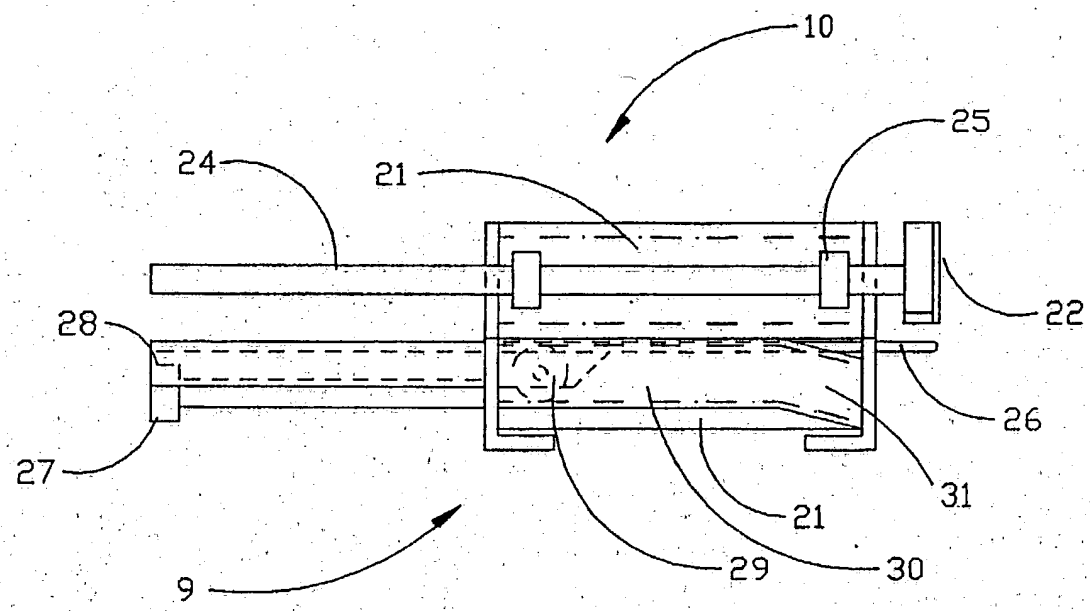

FIG. 9

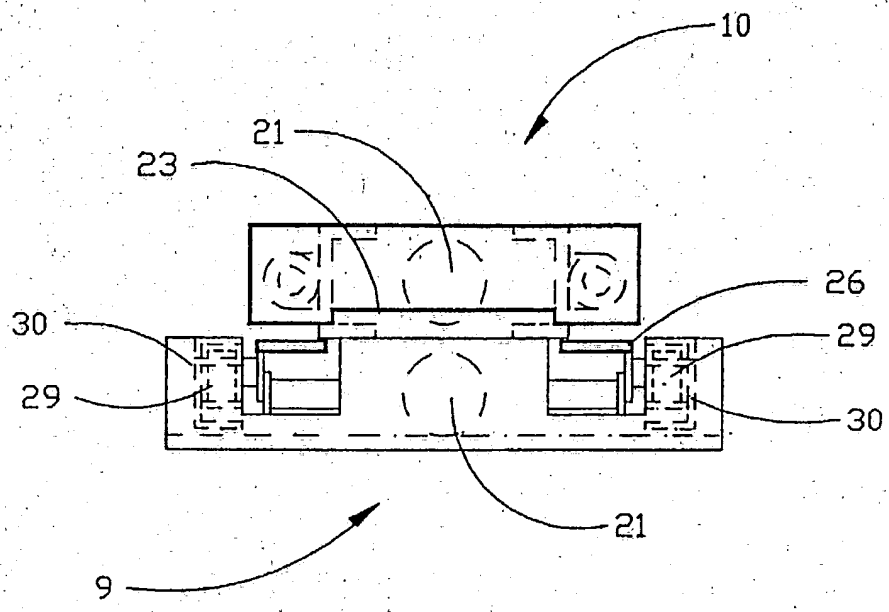

FIG. 10

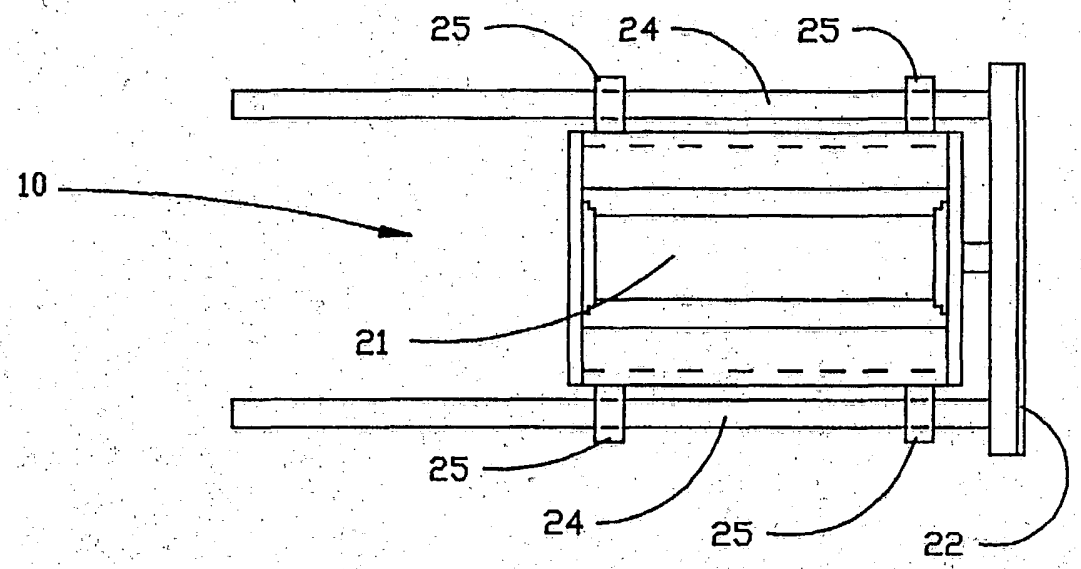

FIG. 11

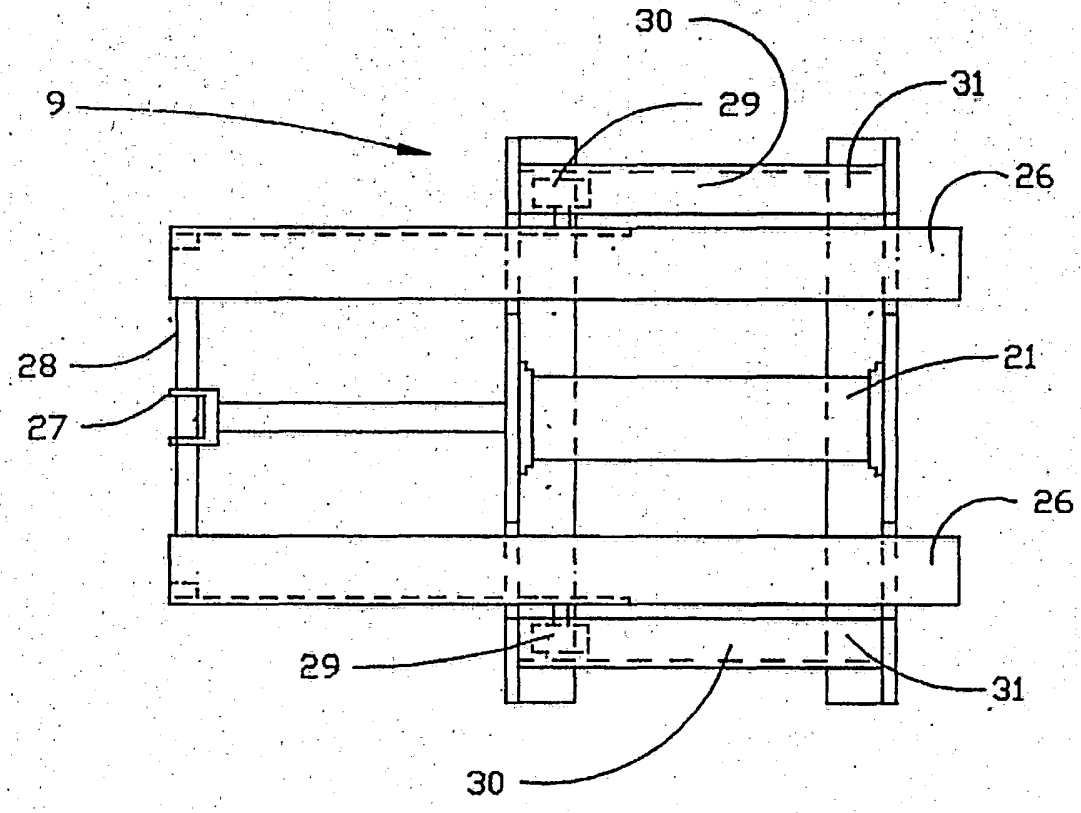

FIG. 12

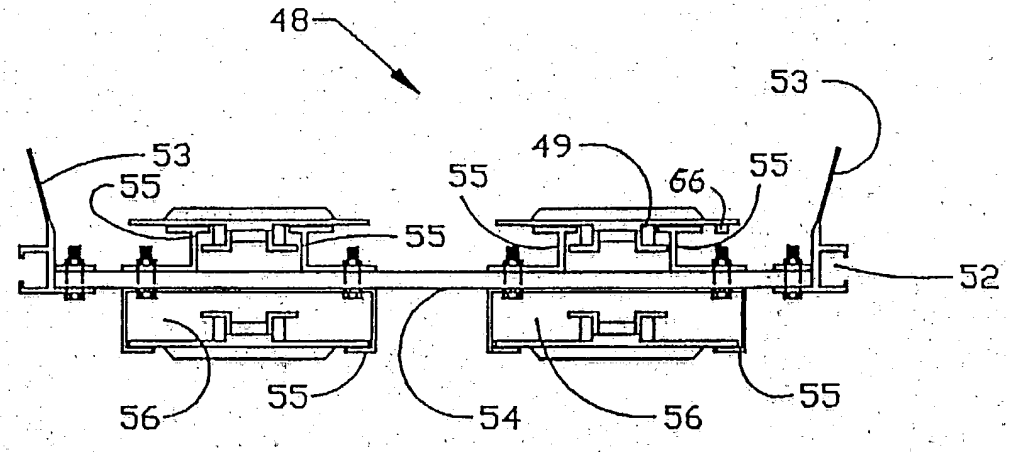

FIG. 13

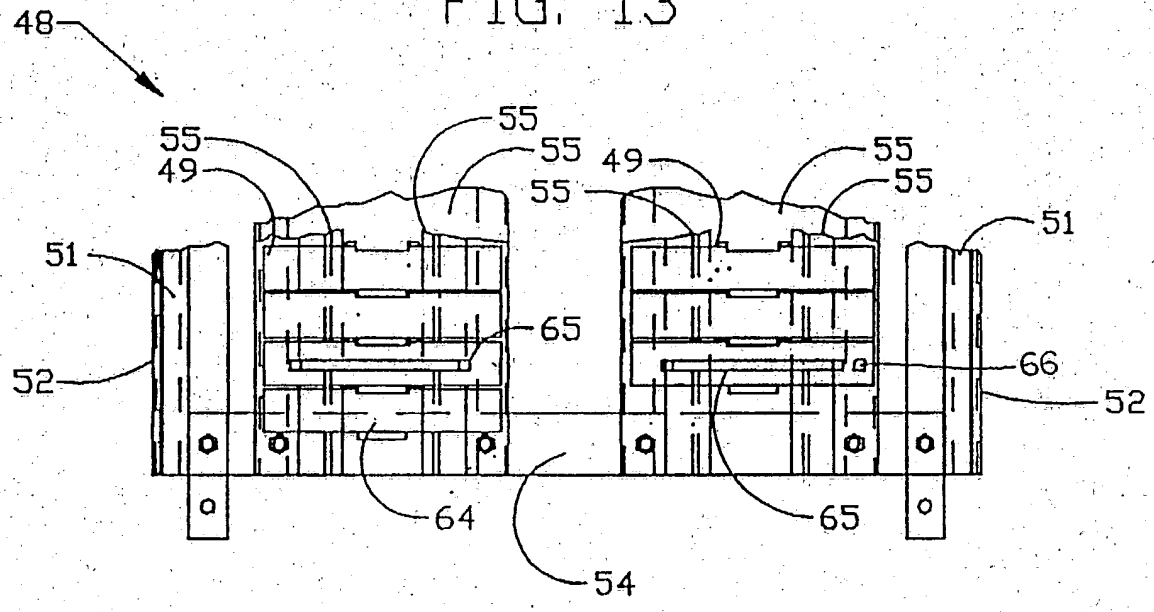

FIG. 14

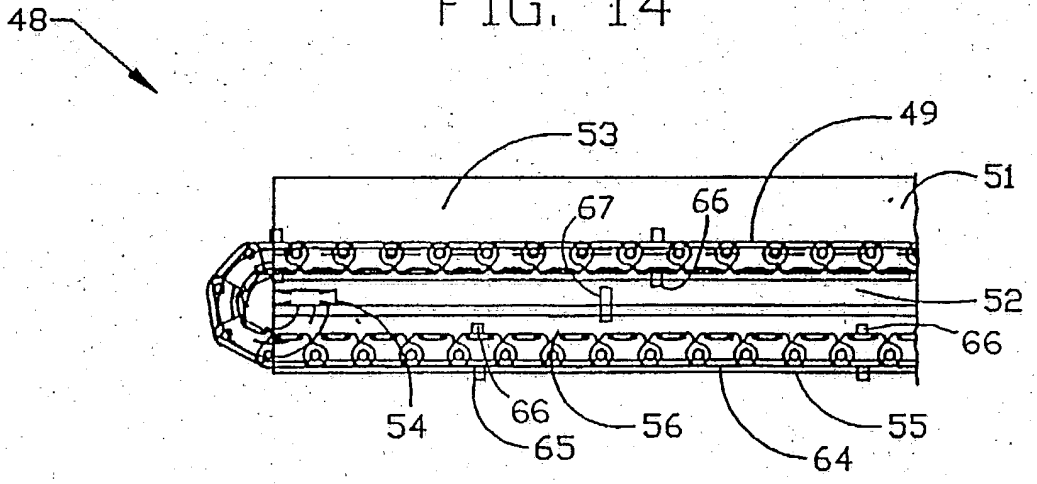

FIG. 15

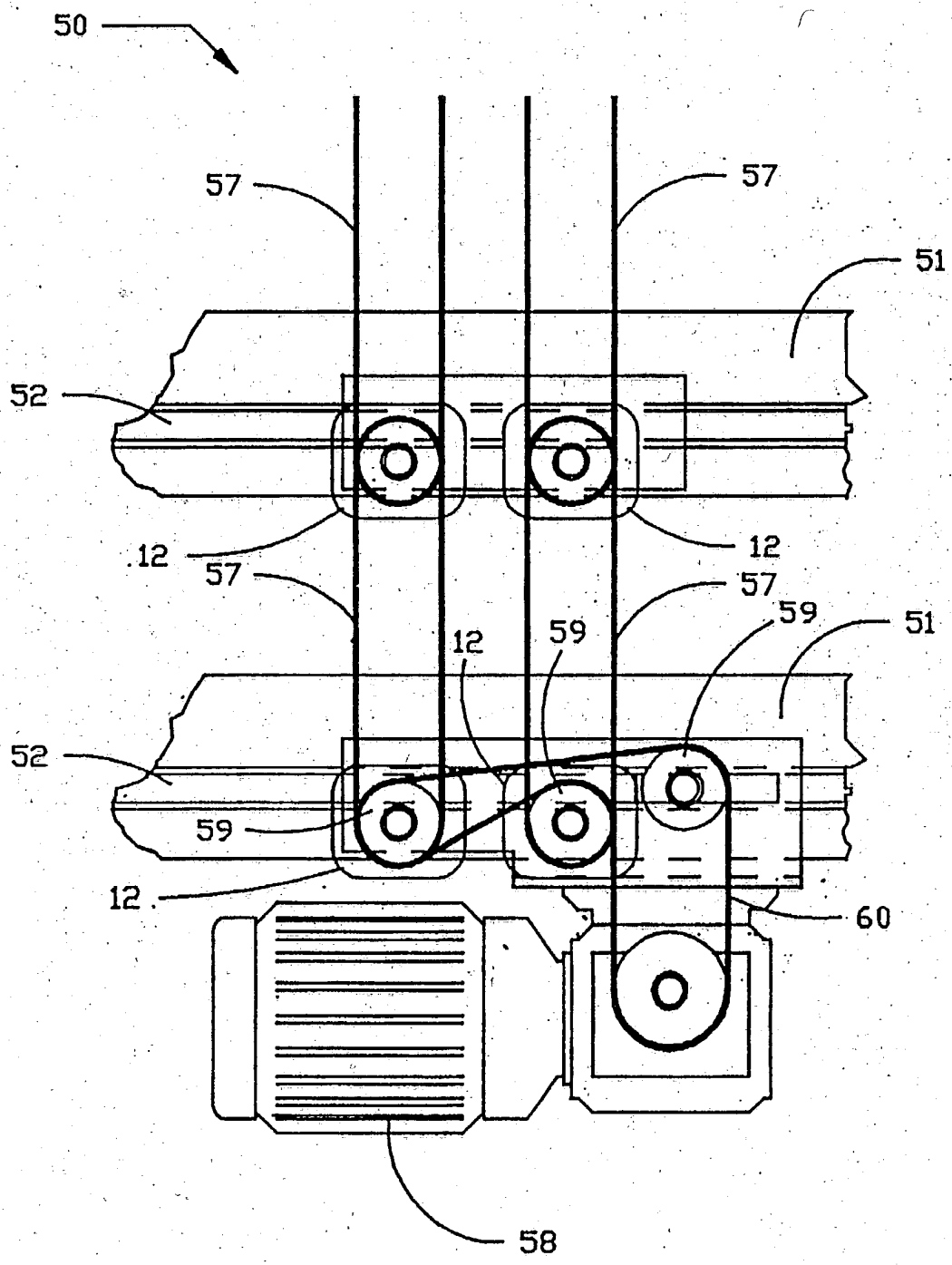

FIG. 16

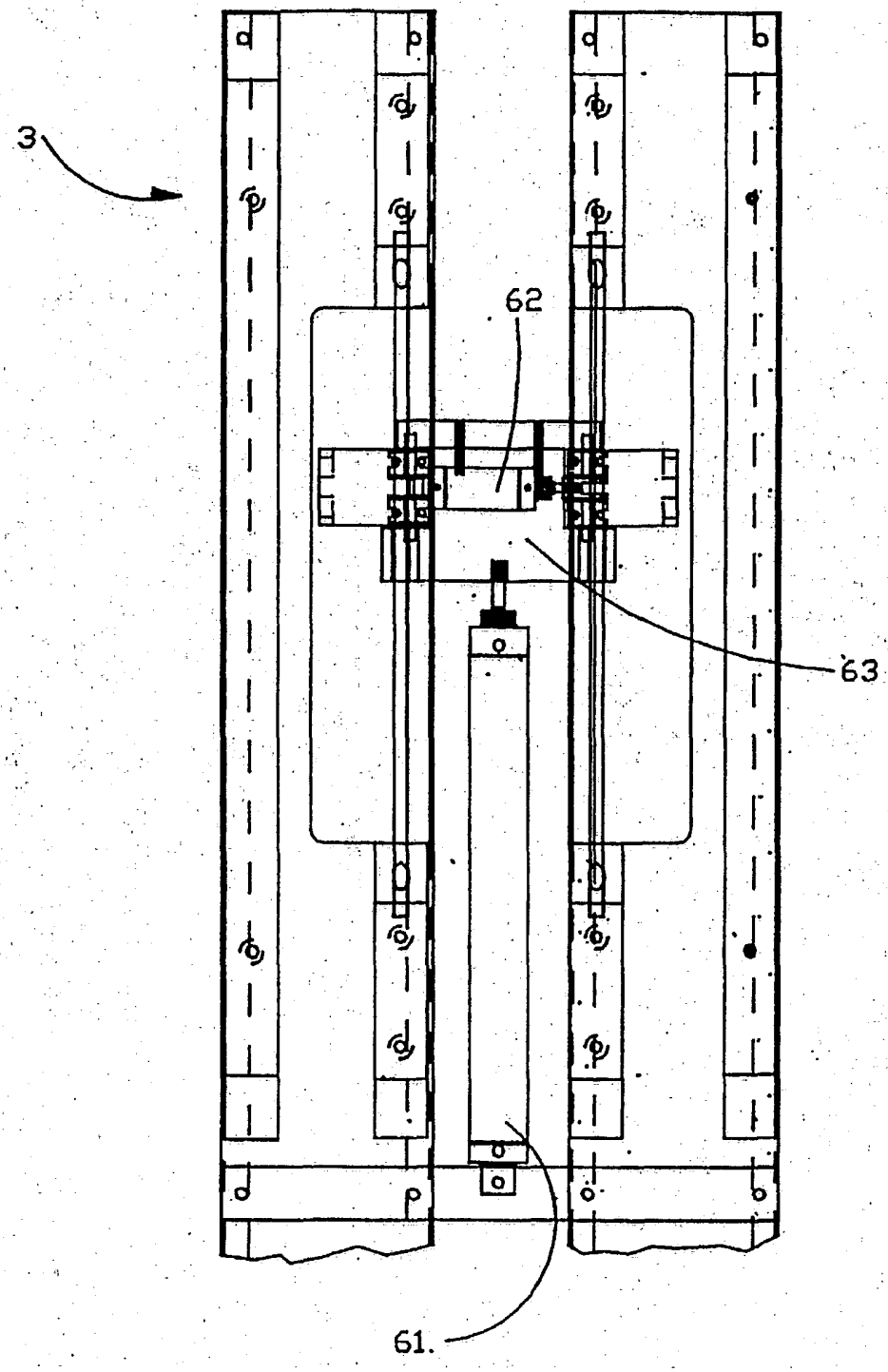

FIG. 17

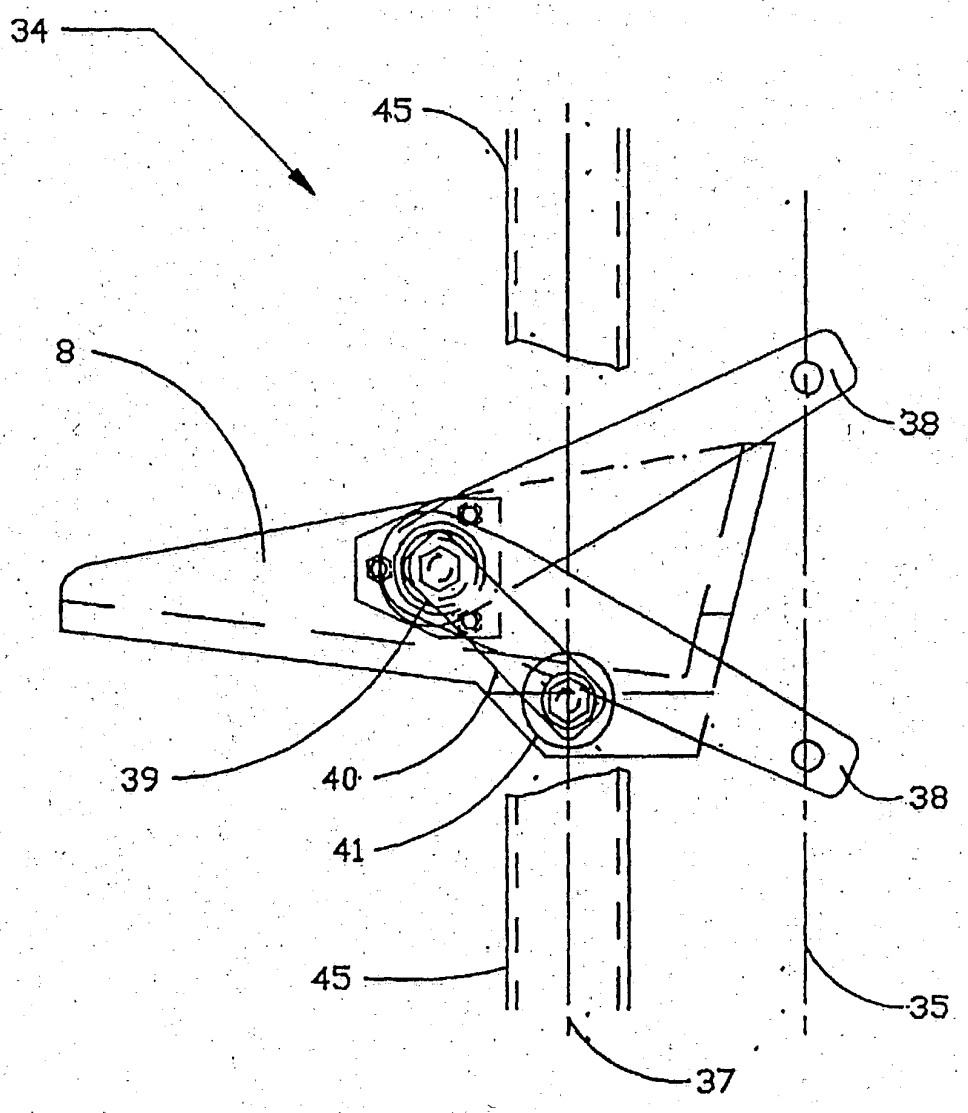

FIG. 18

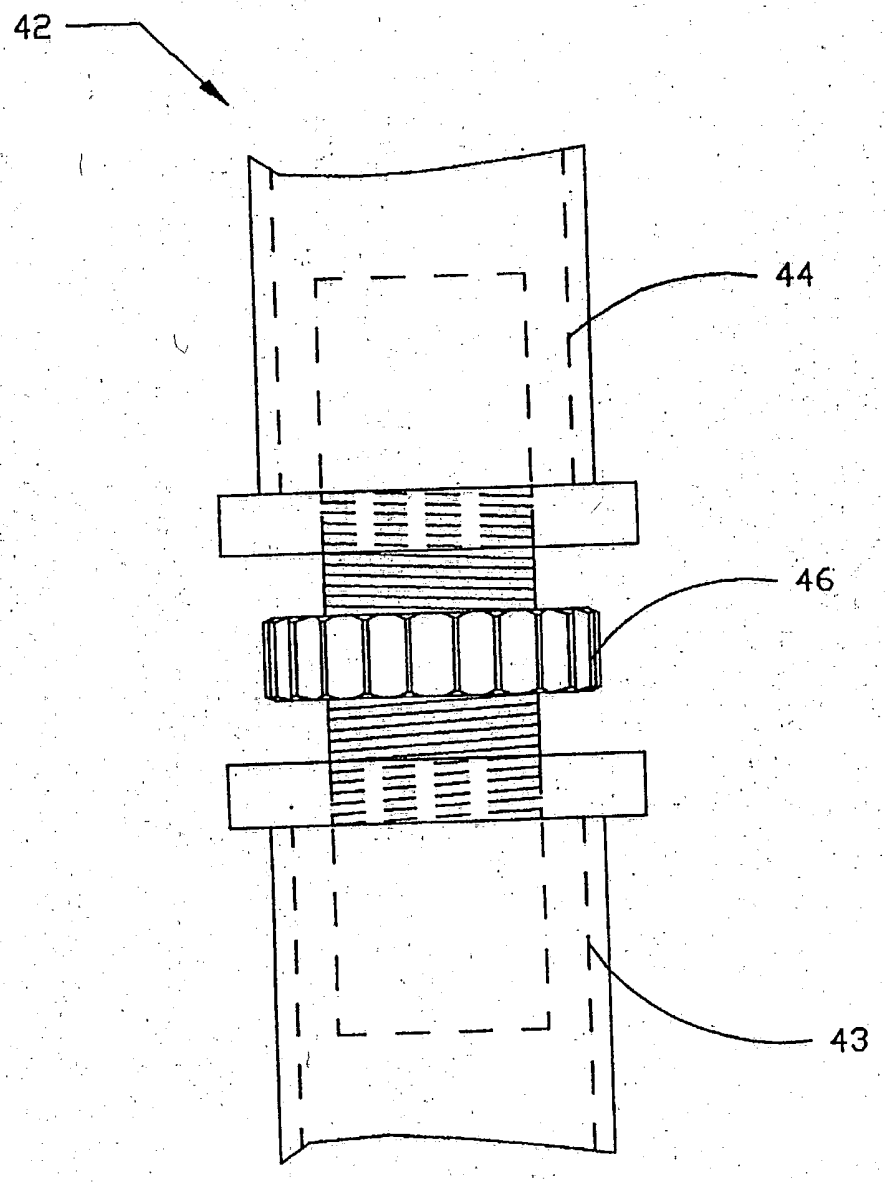

FIG. 19

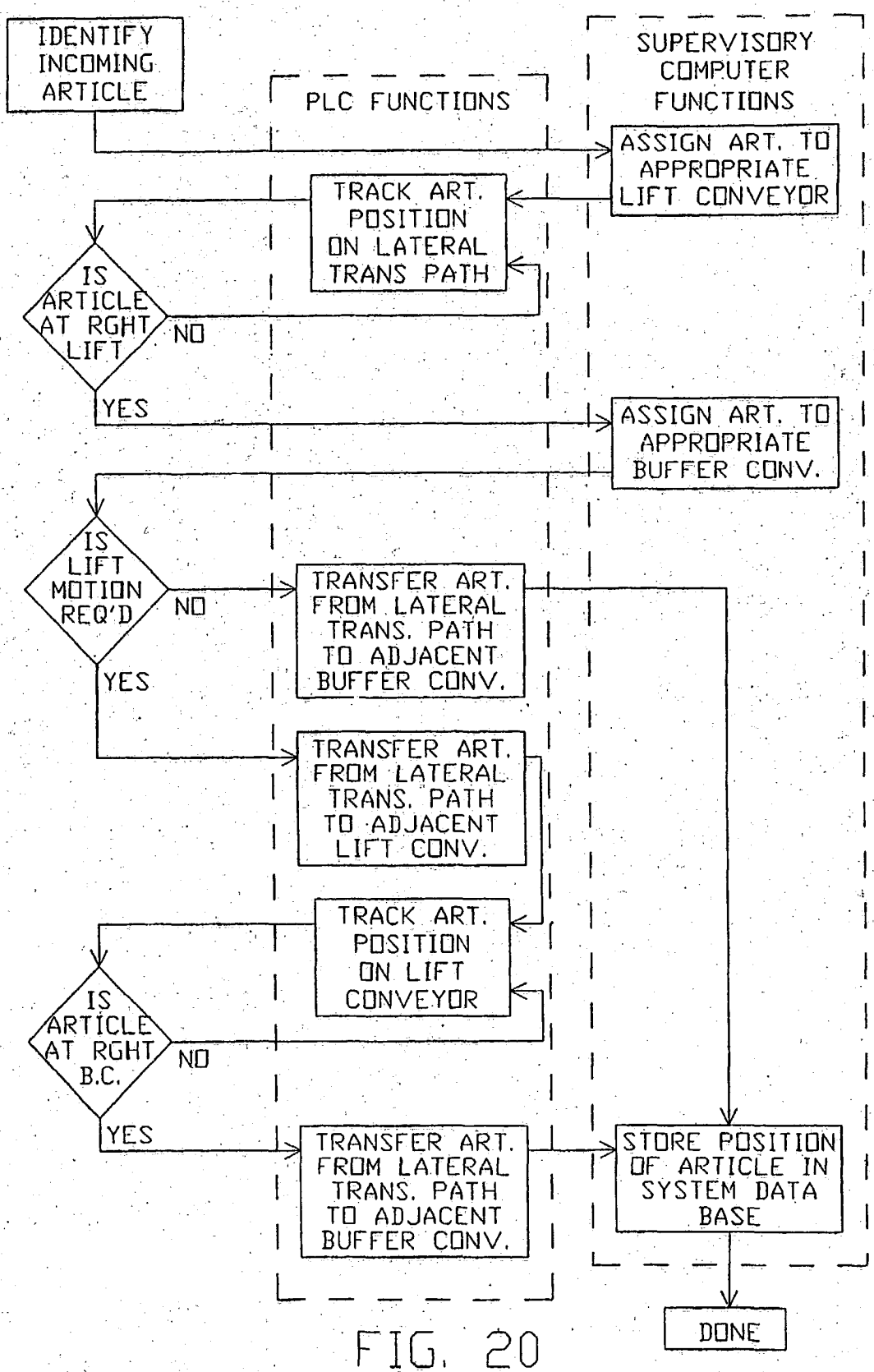
IDENTIFY INCOMING ARTICLE
PLC FUNCTIONS
SUPERVISORY COMPUTER FUNCTIONS
ASSIGN ART. TO APPROPRIATE LIFT CONVEYOR
TRACK ART. POSITION ON LATERAL TRANS PATH
IS ARTICLE AT RGHT LIFT
NO
YES
ASSIGN ART. TO APPROPRIATE BUFFER CONV.
IS LIFT MOTION REQ'D
NO
YES
TRANSFER ART. FROM LATERAL TRANS. PATH TO ADJACENT BUFFER CONV.
TRANSFER ART. FROM LATERAL TRANS. PATH TO ADJACENT LIFT CONV.
TRACK ART. POSITION ON LIFT CONVEYOR
IS ARTICLE AT RGHT B.C.
NO
YES
TRANSFER ART. FROM LATERAL TRANS. PATH TO ADJACENT BUFFER CONV.
STORE POSITION OF ARTICLE IN SYSTEM DATA BASE
DONE

FIG. 20

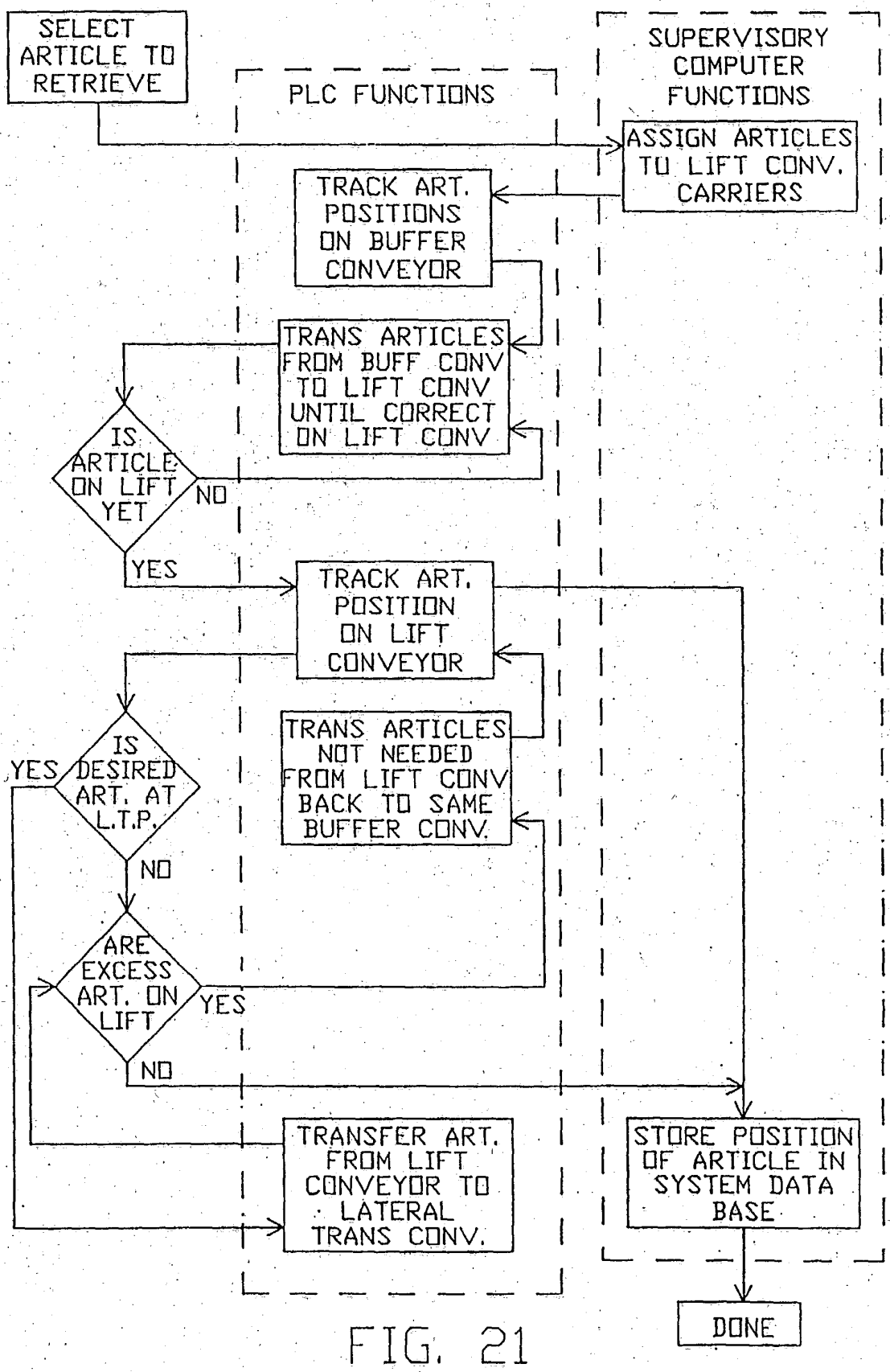
SELECT ARTICLE TO RETRIEVE
PLC FUNCTIONS
SUPERVISORY COMPUTER FUNCTIONS
ASSIGN ARTICLES TO LIFT CONV. CARRIERS
TRACK ART. POSITIONS ON BUFFER CONVEYOR
TRANS ARTICLES FROM BUFF CONV TO LIFT CONV UNTIL CORRECT ON LIFT CONV
IS ARTICLE ON LIFT YET
NO
YES
TRACK ART. POSITION ON LIFT CONVEYOR
TRANS ARTICLES NOT NEEDED FROM LIFT CONV BACK TO SAME BUFFER CONV.
IS DESIRED ART. AT L.T.P.
YES
NO
ARE EXCESS ART. ON LIFT
YES
NO
TRANSFER ART. FROM LIFT CONVEYOR TO LATERAL TRANS CONV.
STORE POSITION OF ARTICLE IN SYSTEM DATA BASE
DONE

FIG. 21

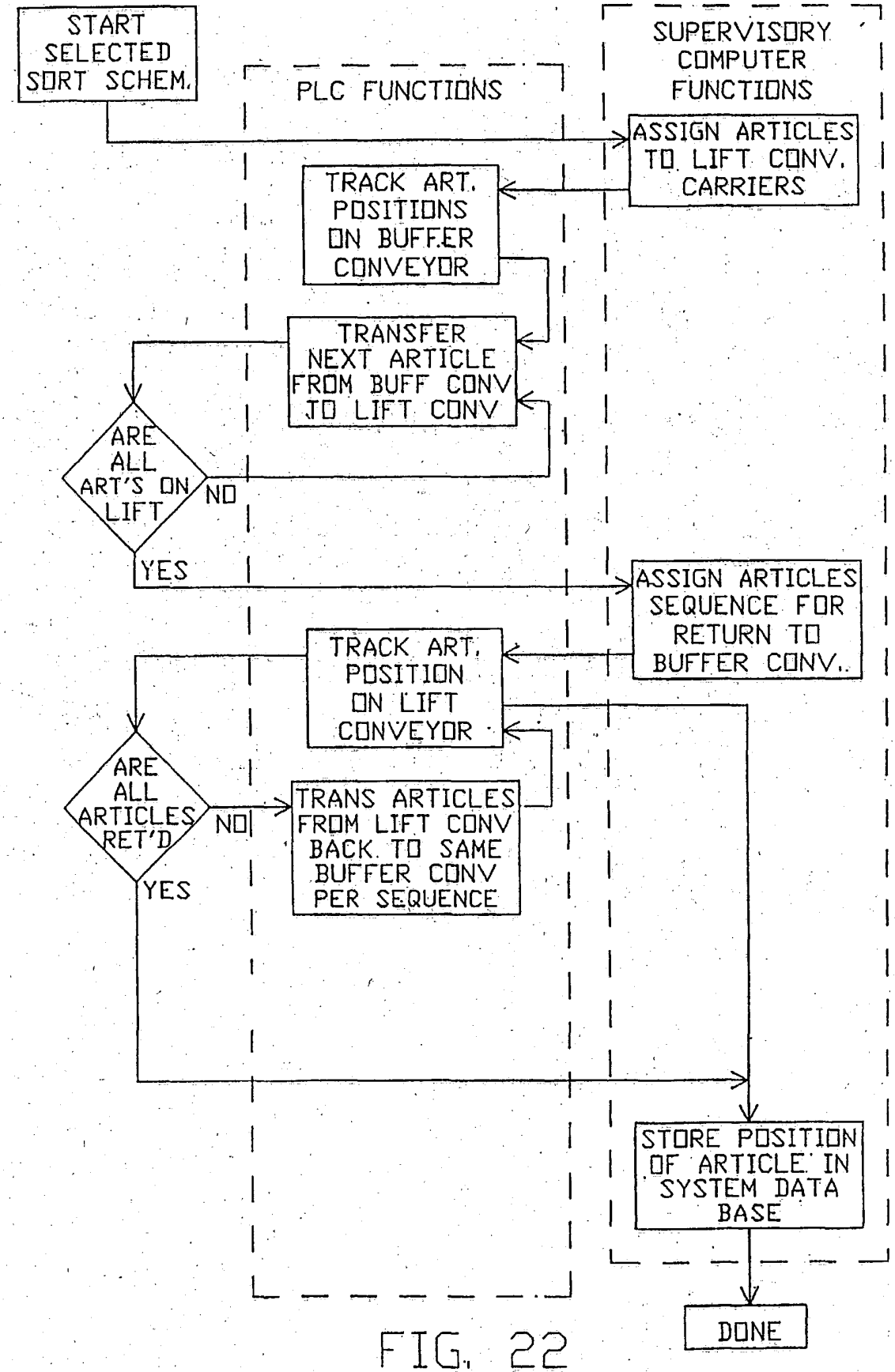
START SELECTED SORT SCHEM.
PLC FUNCTIONS
SUPERVISORY COMPUTER FUNCTIONS
ASSIGN ARTICLES TO LIFT CONV. CARRIERS
TRACK ART. POSITIONS ON BUFFER CONVEYOR
TRANSFER NEXT ARTICLE FROM BUFF CONV TO LIFT CONV
ARE ALL ART'S ON LIFT
NO
YES
ASSIGN ARTICLES SEQUENCE FOR RETURN TO BUFFER CONV.
TRACK ART. POSITION ON LIFT CONVEYOR
ARE ALL ARTICLES RET'D
NO
TRANS ARTICLES FROM LIFT CONV BACK TO SAME BUFFER CONV PER SEQUENCE
YES
STORE POSITION OF ARTICLE IN SYSTEM DATA BASE
DONE

FIG. 22

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/00385

A. CLASSIFICATION OF SUBJECT MATTER

IPC(5) :B65G 1/00
US CL :414/331

According to International Patent Classification (IPC) or to both national classification and IPC

B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

U.S. : 414/273,278,285,787,198,247.2,347.3,347.4,362,366,370,832.1

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

none

C. DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
X Y	US,A, 4,909,697 (Brnard, II et al.) 20 March 1990 See col. 2-4.	1,3,15 2,13,5,14,6,7,8,9, 16-21,22
Y	DE,A, 3,826,875 (Strasse et al) 15 February 1990 See English Synopsis.	5
Y	US,A, 2,606,646 (Madiera) 12 August 1952 See col. 3, lines 40-75.	14
Y	US,A, 4,874,281 (Bergerioux et al.) 17 October 1989 see col. 21 lines 38-66.	14,13,16-19, 21,22

[X] Further documents are listed in the continuation of Box C. [ ] See patent family annex.

*	Special categories of cited documents:	"T"	later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention
"A"	document defining the general state of the art which is not considered to be part of particular relevance	"X"	document of particular relevance; the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone
"E"	earlier document published on or after the international filing date	"Y"	document of particular relevance; the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art
"L"	document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)	"&"	document member of the same patent family
"O"	document referring to an oral disclosure, use, exhibition or other means		
"P"	document published prior to the international filing date but later than the priority date claimed		

Date of the actual completion of the international search 02 MARCH 1993	Date of mailing of the international search report 22 MAR 1993
Name and mailing address of the ISA/US Commissioner of Patents and Trademarks Box PCT Washington, D.C. 20231 Facsimile No. NOT APPLICABLE	Authorized officer STEPHEN T. GORDON NGUYEN NGOC-HO INTERNATIONAL DIVISION Telephone No. (703) 308-2556

Form PCT/ISA/210 (second sheet)(July 1992)*

INTERNATIONAL SEARCH REPORT

International application No.
PCT/US93/00385

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

Category*	Citation of document, with indication, where appropriate, of the relevant passages	Relevant to claim No.
Y	US,A, 4,306,646 (Magni) 22 December 1981 See col. 3, lines 30-40.	13
Y	JP,A, 249,804 (Tanaka) 30 October 1987 See English synopsis.	8,9
Y	US,A, 4,348,152 (Takamatsu) 7 September 1982 See col. 4, lines 13-25.	6,7,8,9
Y	US,A, 4,458,152 (Bonora) 3 July 1984 See col. 4, lines 49-68.	21,22

INTERNATIONAL SEARCH REPORT

Intern...onal application No.
PCT/US93/00385

Box I Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)

This international report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

Box II Observations where unity of invention is lacking (Continuation of item 2 of first sheet)

This International Searching Authority found multiple inventions in this international application, as follows:
(Telephone Practice)
Group I, claim 5, Drawn to an invention of Fig. 17 classified in class 198/832.1

Group II, claim 4, drawn to an invention of Fig. 16 classified in class 414/331.

Election of species requirement between drive systems of fig's 16 and 17.

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

Remark n Protest

☐ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.